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# Cognitive Aspects of Embodied Conversational Agents

Cameron Gavin Smith

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## **Abstract**

Embodied Conversational Agents (ECA) seek to provide a more natural means of interaction for a user through conversation. ECA build on the dialogue abilities of spoken dialogue systems with the provision of a physical or virtual avatar. The rationale for this Thesis is that an ECA should be able to support a form of conversation capable of understanding both the content and affect of the dialogue and providing a meaningful response. The aim is to examine the cognitive aspects of ECA attempting such conversational dialogue in order to augment the abilities of dialogue management. The focus is on the provision of cognitive functions, outside of dialogue control, for managing the relationship with the user including the user's emotional state. This will include a definition of conversation and an examination of the cognitive mechanisms that underpin meaningful conversation.

The scope of this Thesis considers the development of a Companion ECA, the 'How Was Your Day' (HWYD) Companion, which enters into an open conversation with the user about the events of their day at work. The HWYD Companion attempts to positively influence the user's attitude to these events. The main focus of this Thesis is on the Affective Strategy Module (ASM) which will attend to the information covering these events and the user's emotional state in order to generate a plan for a narrative response. Within this narrative response the ASM will embed a means of influence acting upon the user's attitude to the events.

The HYWD Companion has contributed to the work on ECA through the provision of a system engaging in conversational dialogue including the affective aspects of such dialogue. This supports open conversation with longer utterances than typical task-oriented dialogue systems and can handle user interruptions. The main work of this Thesis provides a major component of this overall contribution and, in addition, provides a specific contribution of its own with the provision of narrative persuasion.

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# 1. Introduction

## 1.1. Introduction to Embodied Conversational Agents

Conversation has long been seen as the future of human-computer interaction. Speech is the instinctive means of communication between humans and it is therefore natural to aspire to talking with a computer as if with another human. This is the goal of Embodied Conversational Agents (ECA), to provide a more natural means of interaction for a user. ECA build upon spoken dialogue systems that process the user's speech and respond with synthesised speech of their own. As these interactions are carried out through dialogues, that is, discussing with the computer as with another human being, the system must understand user utterances within a dialogue context. Allen et al (2001) highlight the difficulties of processing full, unbounded conversational dialogue and introduce the concept of 'practical dialogue' as follows:

*The Practical Dialogue Hypothesis:* The conversational competence required for practical dialogues, while still complex, is significantly simpler to achieve than general human conversational competence.

And so it is that classic dialogue systems such as TRAINS (Allen et al, 1995), TRIPS (Ferguson and Allen, 1998) and 'How May I Help You' (HMIHY) (Gorin et al, 1997) constrain themselves to task-oriented dialogues in order to manage the complexities of dialogue itself. For example, the TRAINS project is a dialogue system for collaborative planning operating within a railroad freight domain. This involves both a Domain Plan Reasoner, reasoning over the state of the TRAINS world (such as the locations of the various engines and boxcars along with the movement required of them), and a Dialogue Manager, for maintaining the flow of conversation and attempting to meet the conversational goals of the system.

The field of ECA research seeks to extend this work; ECA are distinguished from spoken dialogue systems by their use of a physical or virtual avatar in their interaction with the user. The embodiment of the ECA essentially provides a face as a focal point for the interaction with the user. Indeed, Cassell (2001) suggests ECA should be modelled on the basis of face-to-face conversation. Cassell et al (2001) highlight some of the benefits of such an approach as intuitiveness and the social nature of the interaction. These elements hinge on the natural inclination of a human to communicate via conversation and, having done so, to establish relationships as a result (even if that

means attributing anthropomorphic properties to a computer system in order to do so). Thus the communication with the system is strengthened by appealing to these natural instincts within the user.

In effect, this presentation of an ECA elevates it from an interface used to carry out a task, as with a spoken dialogue system, to an independent agent with which the user will work in partnership. Yet if an ECA is to respond correctly to the social nature of the interaction it must meet certain expectations from the user. As such, ECA research has begun to look at aspects of the personification of ECA such as personality and emotion. For example, the ECA should exhibit a sense of identity which the user can recognise and anticipate. Further, it should recognise emotion in the user and be capable of expressing emotions itself.

This provides certain challenges for the handling of dialogue with ECA. If the presentation of the agent serves to promote interaction as with a human, so the user will gain the expectation that the agent will respond to conversational dialogue as if it was a human. This is incompatible with practical dialogue as, at the very least, practical dialogue's singular focus on the task, to the exclusion of social dialogue and emotion, is likely to undermine the relationship with the user and thus negate the benefits of using an ECA. However, it also presents an opportunity to harness these benefits by exploring dialogue outside of task-oriented applications and engaging with the user on a more personal and affective level. This, then, is the rationale for this Thesis: that an ECA be able to support a form of conversational dialogue with a user that can show an appreciation of both the content and affective aspects of dialogue and provide a meaningful response.

Traditionally spoken dialogue systems have been broken down based on their area of control: dialogue models, task models, domain or world models and user models. This is a conceptual delineation rather than a practical one; in implementation terms there may be no distinction and certain models may not be covered. Nevertheless, as dialogue systems grow increasingly complex it is useful to segregate areas of functionality. The TRAINS project (Allen et al, 1995) is considered one of the first dialogue systems with a sophisticated task model that is distinct from its dialogue model. Dahlbäck and Jönsson (1999) further advocate the inclusion of task models as separate modules from those providing dialogue management. Thus it can be envisaged that the provision of conversational dialogue be split into component modules such as a dialogue manager



along with auxiliary modules providing specialised functionality facilitating conversation.

## **1.2. Thesis Aims and Objectives**

The aim of the work presented in this Thesis is to examine the cognitive aspects of ECA attempting conversational dialogue. The intent is not to focus on dialogue management itself but rather to augment the existing state of the art in dialogue management. This would consist of a distinct module supporting the dialogue manager with the provision of cognitive functions and applied knowledge. In attempting to break away from task-oriented dialogue it would not be appropriate to categorise this as a task model. Rather these cognitive functions would contribute to the management of the relationship with the user (outside of dialogue control). This would include provision for the emotional aspects of the relationship alongside contributions to the content of conversation. Thus the objective of this Thesis is to discuss the development of such a module including a definition of conversation and examination of the cognitive mechanisms that underpin meaningful conversation.

## **1.3. Thesis Structure**

Subsequent to this introduction, this Thesis presents the following chapters:

- Chapter 2 presents ‘ECA as Affective Dialogue Systems’ which provides further discussion of the current state of the art in ECA. The focus here is on the dialogue abilities of ECA and the overlap with connected fields including affective dialogue systems and persuasive systems. Thus this chapter provides a background for the work of this Thesis.
- Chapter 3 then presents ‘ECA as Companions’ which introduces the concept of a Companion as used in the COMPANIONS project. Further, this chapter introduces the ‘How Was Your Day’ (HWYD) Companion prototype, on which the work of this Thesis will focus, and discusses how the HWYD Companion fits into the previously discussed state of the art in ECA. Thus this chapter provides the context for the work of this Thesis.
- Chapter 4 presents ‘From Dialogue to Conversation’ which examines dialogue genres in order to provide a definition of conversation. This leads to the presentation of a set of challenges to accomplishing conversational dialogue and

discusses how these are met by the HWYD Companion. Thus this chapter further develops the objectives for the work of this Thesis.

- Chapter 5 presents ‘Persuasion through Narrative’ which introduces discussion of the Affective Strategy Module (ASM). The ASM is the focus for this Thesis and is responsible for the generation of the HWYD Companion’s narrative responses. This chapter presents the basis for the means of influence employed by the ASM and details the analysis of a user’s situation and subsequent selection of an affective strategy. Thus this chapter presents the philosophy behind and the implementation of the initial portion of work of this Thesis.
- Chapter 6 presents ‘Planning Narrative Responses’ which provides details of the planning approach employed by the ASM. The range of affective strategies covered by the ASM is illustrated with dialogue excerpts from the completed HWYD Companion. Thus this chapter further details the implementation of the work of this Thesis.
- Chapter 7 presents ‘Results’ which provides details of the fully working HWYD Companion prototype. This includes discussion of extended dialogues taken from the working system. Thus this chapter assesses the work of this Thesis with respect to the completed system.
- Finally, Chapter 8 presents the ‘Conclusion’ where the contributions of this Thesis are reviewed and areas of further development are discussed.

## **2. ECA as Affective Dialogue Systems**

### **2.1. Introduction**

ECA research spans a myriad of areas from conversational functions for managing a dialogue to expressive agents capable of showing personality and emotion. This Thesis will mainly be focusing upon the ability of ECA to communicate and persuade. Thus this chapter considers further those ECA involved in dialogue. Several implementations of ECA are discussed leading onto discussion of ECA within related fields including affective dialogue systems and persuasive systems. However, it is first important to reconsider what is understood by dialogue when used in the context of ECA.

### **2.2. Dialogue is more than speech**

Dialogue should not be thought of as merely consisting of speech. In adding embodiment to the agent, ECA possess multiple means of interaction compared to spoken dialogue systems. This multimodal nature of conversation allows information to be communicated via several independent routes and for the focus to be given to any particular modality as appropriate (Cassell et al, 2001). Speech is certainly the main modality for dialogue but there are several non-verbal behaviours that can be brought into play (Cassell, 2001). Gestures often accompany speech in human-to-human conversation and a range of gestures are used to reinforce the speaker's intent. Facial expressions can be used to present interactional functions, emotion, personality and performatives. Performatives relate the communicative intent behind an utterance. That is, they attempt to convey the reason that a given conversational function is employed. Poggi and Pelachaud (2001) discuss in detail the use of facial expressions in conveying performatives. Such expressions may be used to reinforce, replace or even alter the meaning of a given utterance. Eye gaze is also important for interactional functions and can even convey elements of emotion or personality.



**Figure 2.1:** *Examples of Embodied Conversational Agents. Clockwise from top left: Steve, Justina (Virtual Patient), Cloddy Hans (NICE), REA, Hans Christian Andersen (HCA), Mission Rehearsal Environment, GRETA and LAURA (FitTrack). (See Appendix A for image sources.)*

### 2.3. Applications of Embodied Conversational Agents

There are a range of applications across which ECA are employed and a range of implementations of ECA which have been created within them. Figure 2.1 shows some of the ECA discussed in this chapter. Dialogue is an integral part of the function provided by each of these ECA and we now consider the extent to which conversational dialogue is supported in each.

#### 2.3.1. Steve

One common application for ECA is as pedagogical agents teaching a user about a given subject or how to perform a given task. Steve (Johnson and Rickel, 1997), the SOAR Training Expert for Virtual Environments, is a fully embodied male avatar within a Virtual Reality environment. Within the initial domain, the operation and maintenance of gas turbine engines aboard naval ships, Steve demonstrates (using embodiment) and explains (using synthesised speech) a given procedural task to a student and can then respond to questions from the student (processed via speech recognition). Steve's cognitive abilities are provided by the SOAR cognitive architecture (Laird et al, 1987). Multiple Steve agents can be used for team-based training (Rickel and Johnson, 1999).

Steve is one of the earliest ECA and offers a good integration of modalities. For example, Steve is able to point at items, such as a button, while discussing their function. Steve also offers a good level of dialogue depth, employing the complex task model to answer questions about the procedure being demonstrated and the rationale behind specific actions. However, the dialogue is strictly task-focused and limited to the expert domain that Steve demonstrates. As such, Steve is not equipped to respond to more general conversational dialogue.

### **2.3.2. Virtual Patient (Justin/Justina)**

In addition to teaching, ECA may be employed in a training capacity which allows users to practice previously acquired skills. Kenny et al (2007) present a Virtual Patient architecture providing agents able to simulate patient behaviour during interviews by doctors. The Virtual Patients are full bodied agents inside a virtual environment capable of a full range of gestures and facial expressions synchronised with pre-recorded speech. They carry out speech recognition on user utterances, using the analysed results to select the most appropriate response. The initial Virtual Patient, Justin, mimics a patient with a conduct disorder. Kenny et al (2008) follow this up with a new Virtual Patient, Justina, applying the work towards patients with Post-Traumatic Stress Disorder.

This application immediately places ECA in a more conversational context, allowing the user to interview a patient seemingly outside of a task-oriented setting. The use of pre-recorded speech combined with agent embodiment allows the Virtual Patient to ably emulate the experience of interviewing a real patient. Yet this application is not attempting to offer free conversation and the dialogue is notably constrained. Not only is the dialogue heavily focused on the chosen medical domain (conduct disorder or PTSD depending on the agent) but the pre-recorded speech ensures that dialogue is effectively controlled through multiple choice selection rather than guided by the user's actual utterances.

### **2.3.3. The NICE project**

ECA may be employed purely for the purpose of interaction with the user. Gustafson et al (2005) present work from the NICE project showing a 3D game with a fairy-tale setting which features two fully embodied characters (a male and a female character). The system is capable of multi-party dialogue, with the characters understanding speech

from the user and responding with speech, gestures and facial expressions. This presents a twist on task-oriented dialogues as rather than completing a practical task, the user is interacting with characters to solve puzzles in the game environment as part of an overarching story. Yet the domain still constrains the dialogue and the user cannot engage in conversation outside of the ‘story-functional events’ that specify the game.

#### **2.3.4. SDO Moleno and the Virtual Salesclerk**

ECA may also be employed inside virtual environments such as Second Life<sup>1</sup>. Jan et al (2009) present a fully embodied agent who acts as Staff Duty Officer at the US Army’s island within the Second Life virtual world. SDO Moleno communicates with visitors over text chat (both in-world chat and direct instant messaging), answering their questions, and is also capable of acting as a guide within the virtual world to direct visitors to specific exhibits. Mumme et al (2009) present a Virtual Salesclerk, an embodied agent acting as a salesclerk inside a virtual video store environment created using OpenSim/Second Life. The agent communicates with the user using text chat and gestures, with dialogue taking a ChatterBot approach (further discussed later in this Thesis) which models 5 phases in the sales process.

These two ECA interact using text chat rather than speech but are still capable of holding dialogues with a user. The dialogues are not task-oriented in that they do not feature a specific task to be accomplished. However, they are both constrained by their respective domains (answering questions and providing directions about the US Army’s island for SDO Moleno and discussing video sales for Virtual Salesclerk) rather than offering free, open conversation. While this is not as constrictive as a task-oriented dialogue, the ChatterBot approach employed does not allow for much depth to the conversation.

#### **2.3.5. REA**

However, both approaches have also been combined to harness the benefits of each. REA (Cassell et al, 1999), the Real Estate Agent, acts as an agent attempting to sell a real estate property to the user. REA is represented as a fully embodied female avatar projected on a large screen and is capable of speech and gesture output while responding to the speech and gestures of the user. Within this task-oriented dialogue, REA may also employ small talk in order to build up the relationship between the user

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<sup>1</sup> <http://secondlife.com/>

and the agent (Bickmore and Cassell, 2001). The aim is to facilitate a more favourable outcome when the agent returns to the task-oriented aspects of the conversation. Both REA and the ChatterBot approach will be discussed in more detail in Chapter 4.

#### **2.3.6. Hans Christian Andersen**

Outside of ChatterBots there are few ECA which attempt more open conversation without a specific task. The HCA system (Bernsen and Dybkjær, 2004) provides a virtual Hans Christian Andersen. This is a fully embodied, cartoon representation of Hans Christian Andersen capable of processing user speech and gesture input while communicating through speech, gesture, facial expression, body movement and action. It engages in what is termed ‘domain-oriented conversation’ discussing topics related to the historical Hans Christian Andersen’s life and work.

There is no specific goal to this ‘domain-oriented conversation’ with the HCA system merely attempting to establish a common ground with the user which can then be pursued. If the user attempts to discuss something outside of the HCA’s knowledge base, the system will direct the conversation onto a known subject such that it can share an anecdote about that subject. Ultimately, while the HCA system employs a more complex approach involving dialogue management, the lack of purpose in the conversation combined with a limited domain and a reliance on some scripted responses fails to differentiate the final conversation from that of ChatterBots.

#### **2.3.7. Mission Rehearsal Exercise**

Despite this lack of specifically conversational ECA, there are still ECA which attempt to move away from task-centred dialogue. The MRE (Rickel et al, 2002), or Mission Rehearsal Exercise, is an ECA suite used to train US Army officers. It provides fully embodied agents capable of multimodal input and output that build on the previously discussed Steve agent. The Steve functionality is expanded to provide a more comprehensive task-oriented dialogue system and to emulate emotion and human perception. Traum et al (2005) further augment the MRE system with the ability to perform negotiation. This involves several negotiation strategies (avoidance, distributive and integrative), appraisal of the negotiation (including emotional aspects) and modelling trust. Traum et al (2008) then extend this work to provide a more general and human-like approach to negotiation which covers multiple independent participants who can discuss several issues at once.

This does not provide free, open conversation as the dialogues are still constrained by the nature of the domain (implementing specific scenarios which Army officers may face). However, it does contribute to a more conversational form of dialogue than that of typical ‘practical dialogue’ systems. The task undertaken by the user involves negotiation with one or more ECA characters who, in turn, attempt to emulate the behaviour of real people. This is similar to the Virtual Patient applications described earlier but here involves a much higher degree of simulation on the part of the ECA. Thus the user has much greater freedom in approaching the dialogue and must pay much greater attention to the relational aspects of the dialogue in order to ensure success in the task they have been assigned.

## **2.4. Affective Dialogue Systems**

The MRE also introduces the importance of dealing with emotion. The affective aspect is a relevant part of conversation and further differentiates conversation from task-oriented dialogues. Handling emotion is one of the aspects excised by ‘practical dialogue’ as it does not contribute to the process of managing the task. However, handling emotion appropriately can be vital to the social nature of interaction with ECA (Gratch and Marsella, 2001). Thus with the provision of emotion modelling some ECA cross into the realm of affective dialogue systems.

### **2.4.1. MRE as virtual humans**

Traum et al (2004) have extended their MRE virtual humans with emotion and dialogue models. These rely on a central task model whose task representation supports conditional, decision-theoretic and intentional reasoning. The dialogue model, based on the TRINDI project approach to dialogue management (Larsson and Traum, 2000), is linked to this task model. A snapshot of the dialogue is held within a central Information State (IS). Then the various system and user utterances act as ‘dialogue moves’ which alter the IS.

Meanwhile, the emotion model is informed by the work on appraisal theory (Lazarus, 1991). This posits that (Traum et al, 2004):

emotion arises from a person’s assessment of their relationship with their environment, including not only their current condition but past events that led to this state as well as future prospects.



Thus the agent's emotion is rooted in the task model with its appraisal generating emotion instances and employing coping strategies to manage the emotional reaction. This shared reliance on the task model allows the emotion and dialogue models to reinforce each other with the emotional significance of events influencing the interpretation of new information and colouring the agent's response.

#### **2.4.2. Cavalluzzi et al.**

However, not all ECA rely on simulating the agent's emotional state with some focusing on the emotional state of the user instead. Cavalluzzi et al (2004) present a dialogue system for advising the user on healthy eating practices. The system aims to convince the user to follow a plan for healthier eating, adapting the approach based on the user's attitude. This task involves first recognising the user's current attitude then selecting an appropriate strategy to act upon the user.

Cavalluzzi et al highlight the importance of the affective aspects when attempting persuasive dialogue "in order to establish a relationship of trust and therefore to increase its chance of success". Their system is capable of recognising the emotional state of the user and then simulating an appropriate emotional reaction to show empathy with the user. To help with this, the system can employ an embodied agent (from several options including GRETA) to provide non-verbal communication.

GRETA (Bevacqua et al, 2004) is a fully embodied female avatar capable of providing speech, gestures, facial expressions, gaze and head movements. GRETA is provided as a module that can be integrated with a system to provide an ECA interface and has been used across a range of projects including CALLAS<sup>2</sup>, SEMAINE<sup>3</sup> and HUMAINE<sup>4</sup>. A focus for GRETA is the expressivity of the ECA (Bevacqua et al, 2007) leading to the display of complex agent emotions. This makes it well placed for integration with affective dialogue systems such as the system from Cavalluzzi et al.

The dialogue of the system of Cavalluzzi et al is managed with an Information State Model approach (Traum and Larsson, 2003) as with the dialogue model in the MRE. The flow of the dialogue consists of interleaving the agent's suggestions with questions. These questions are intended to provide points for assessing the user's current attitude

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<sup>2</sup> <http://www.callas-newmedia.eu/>

<sup>3</sup> <http://www.semaine-project.eu/>

<sup>4</sup> <http://emotion-research.net/>

and emotional state. The agent can then continue with the planned strategy (when it is still appropriate) or re-plan the strategy that is to be employed to meet the user's new state. The user's attitude is assessed in terms of the 'State of Change' Model (Prochaska et al, 1992) which identifies six main stages in how a subject changes from employing 'wrong' behaviour towards adopting 'correct' behaviour. The subject's emotional state is connected with the state of change and can be useful in identifying the correct state of change for the user. The system models emotion in terms of valence and arousal following the Circumplex Model of Affect (Russell, 1980).

### **2.4.3. FitTrack**

FitTrack (Bickmore and Picard, 2005) is a similar system where the ECA takes the form of an exercise advisor encouraging users to adopt a certain level of physical activity. It focuses on the relationship with the user over multiple interactions, aiming for daily interactions over the course of a month. The fully embodied vector-graphics-based ECA uses synthesised speech and non-verbal behaviours including gestures and facial expressions. User input is provided through selection from a dynamically updated menu of text phrases. Dialogues were scripted and compiled into Augmented Transition Networks allowing the agent to refer back to previous conversations with utterances tailored at runtime based on the agent's knowledge of the user.

## **2.5. Persuasive Systems**

Bickmore and Sidner (2006) proposes a system utilising dialogue planning, via COLLAGEN (Rich and Sidner, 1998), for health behaviour change with FitTrack acting as an ECA front-end. As with (Cavalluzzi et al, 2004) it employs the 'State of Change' model for managing behaviour change. Thus, while this does not act as an affective dialogue system, both these systems present the use of ECA in persuasive systems. This is useful when considering how the ECA will manage the relationship with the user throughout a conversation.

Persuasive systems attempt to exert some influence upon a user with Tørning and Oinas-Kukkonen (2009) differentiating between a resulting change in behaviour and a change in attitude. The systems presented in (Cavalluzzi et al, 2004) and in (Bickmore and Sidner, 2006) are both attempting a change in user behaviour; for the former this corresponds to the user adopting a healthier diet while in the latter the user will engage in more physical exercise. Meanwhile, presented in (Schulman and Bickmore, 2009) is

a study examining attitude change with a FitTrack-style ECA. Tørning and Oinas-Kukkonen (2009) found that most systems focused on behavioural change: of 32 systems examined, 27 addressed behavioural change with 5 attempting attitude change.

They state:

That behavior was mostly addressed is probably due to the fact that behavior change is in most cases easier to study than attitude change.

## **2.6. Conclusion**

This chapter has detailed a range of dialogue ECA and discussed the extent to which they support conversational dialogue. While none have provided conversational dialogue to the level necessary for the work of this Thesis, they nevertheless serve to lead away from the task-oriented focus of spoken dialogue systems and highlight areas of interest to conversational dialogue. This has included associated work on affective dialogue systems and persuasive systems which inform the approach used to manage the agent's relationship with the user. Having established this background covering previous work on ECA we now look, in the next chapter, at the context for the new work presented in this Thesis.

### **3. ECA and Companions**

#### **3.1. Introduction**

In envisaging an ECA capable of conversation it is necessary to consider the function (in terms of relationship rather than task) which it will perform and thus the application of the ECA. This chapter considers the application for the ECA that will be the focus of this Thesis. In doing so, it introduces the concept of a Companion and discusses the specific scenario in which the work of this Thesis is designed to be used. This ECA is then discussed in contrast to previous ECA in order to establish both the approach and the contribution provided by the work of this Thesis.

#### **3.2. ECA as Personal Assistants**

A potential ECA role not yet well covered is that of some form of personal assistant which will support the user with certain daily tasks. Many agent systems exist that will provide ongoing assistance to a user across a broad range of domains. For example, Myers et al (2007) present the Project Execution Assistant which aims to improve the productivity and effectiveness of an office worker. Another example is the Personalised Cognitive Orthotic (McCarthy and Pollack, 2002) which provides reminders to elderly people experiencing cognitive decline to assist them in managing their daily activities. Such systems would likely profit from the benefits of face-to-face conversation, particularly the intuitiveness and social nature of the interaction, which ECA may provide. These elements are all the more important when taking into account the persistent nature of the interaction.

Most of the ECA discussed previously are transactional in nature, focusing on completing a single interaction with the user whether that be teaching engine maintenance or selling real estate. A personal assistant, in contrast, would be required to repeatedly interact with a user on an ongoing basis thus the efficacy of the continued interaction becomes as important as the success of individual interactions. When the social nature of the interaction is taken into account, with the ECA likely being anthropomorphised by the user, the ECA effectively becomes responsible for maintaining an ongoing relationship with the user.

### **3.3. Companions within the COMPANIONS project**

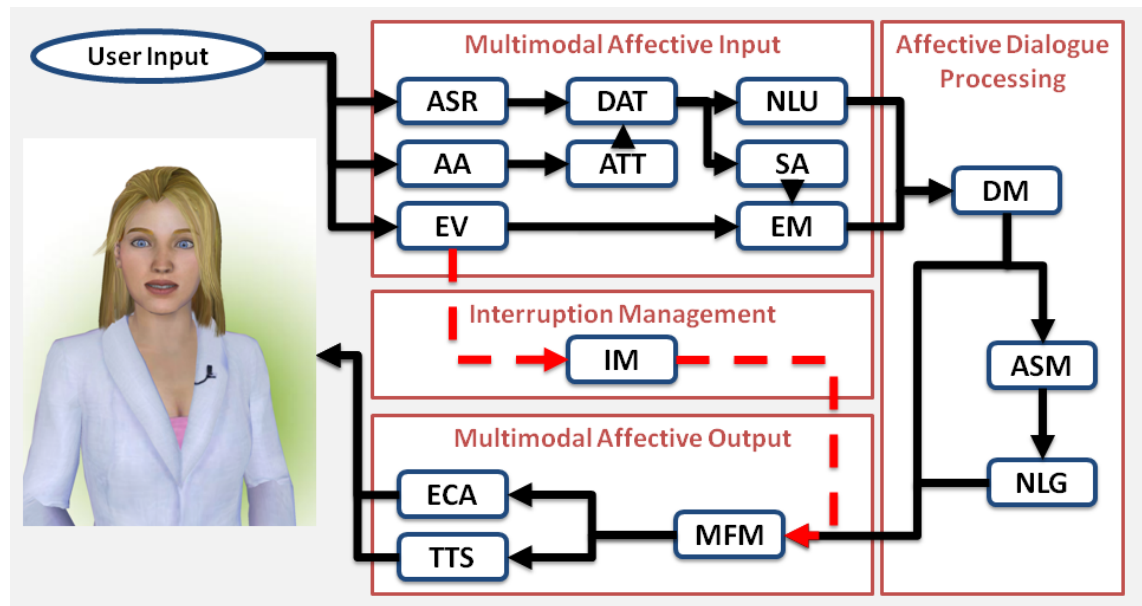
It is this notion of a relationship between user and ECA that defines the concept of a Companion used within the COMPANIONS project. While a Companion is in effect an ECA as personal assistant, this familiarity with and repeated usage of the system alters the approach taken compared to more general agent systems. How the Companion interacts with the user becomes as important, if not more important, than the function provided by the interaction; the Companion is required to provide a social function as well as a practical function. Thus the focus for the design of a Companion is to provide a system capable of natural conversation and of handling the affective aspects of such a conversation. In essence, the role of the Companion is as much about being a supportive friend as being an efficient assistant.

#### **3.3.1. The Health and Fitness Companion**

My initial work on the COMPANIONS project was on the Health and Fitness Companion (HFC). The aim for the HFC was to promote a healthy lifestyle for the user by gathering details of their daily activities and providing suggestions that might improve their behaviour. My contribution to the HFC was the Cognitive Model which maintained an activity model for the user including aspects of both physical activity and diet. From this activity model, the Cognitive Model was able to generate dialogue plans that provided guidance to the Dialogue Manager (DM) on appropriate questions and suggestions for the user. The goal was for the HFC to be able to incorporate this discussion of healthy living within conversations with the user without turning such conversations into explicitly task-focused dialogues.

#### **3.3.2. The ‘How was your day?’ Companion**

However, the focus of this thesis is on the ‘How was your day?’ (HWYD) Companion and more particularly, on my contribution of the Affective Strategy Module (ASM) which generates responses for the user, augmenting the ability of the DM within the HWYD Companion. The HWYD Companion provides a fully embodied female avatar (Figure 3.1) capable of synthesised speech, gestures and facial expressions. The HWYD Companion responds to user speech, processing both semantic and affective aspects of the user utterances.



**Figure 3.1:** The HWYD Companion with an overview of the system components. The ‘main loop’ of processing is shown with the solid black line which passes through the Multimodal Affective Input, Affective Dialogue Processing and Multimodal Affective Output components. The Interruption Manager (IM) handles user interruptions, communicating with all modules as necessary. In addition, the IM coordinates the ‘short loop’ shown with the dashed red line which provides affective feedback.

The envisaged usage scenario for the HWYD Companion is for the Companion to reside in the user’s home. The user, a typical office worker, would initiate conversation with the Companion following their working day. The user would discuss the events of their working day with a particular focus on those things that had affected them emotionally, be that a positive or negative affect. The Companion would engage the user in conversation, eliciting further information as required and returning a response with the aim of providing a positive influence upon the user’s attitude to those events.

### 3.3.3. Overview of the HWYD Companion system

There is great complexity in the overall integrated system with the HWYD Companion involving 15 modules working together to perform the required processing (Figure 3.1). This involves affective input modules processing the user’s speech: Automatic Speech Recognition (ASR) to capture the content and EmoVoice to capture the affective qualities of the voice. Subsequent modules manage additional aspects, such as turn taking, dialogue act tagging, sentiment analysis and emotional fusion. The main affective dialogue processing commences from the Natural Language Understanding

(NLU) module's parsing of the ASR output. This feeds into the DM which determines the Companion's response and invokes the ASM when necessary. These responses are then relayed through the various affective output modules back to the user.

The Interruption Manager (IM) adds a further layer which coordinates the 'short loop' feedback and interruption behaviour across all the modules. The 'main loop' of behaviour includes a route through each system module (excluding the IM) and provides full processing of all information. However, this comes at the cost of a lengthy processing time. This is a problem as the timing of responses can be as important as the responses themselves, with delays potentially indicating an unwillingness to cooperate or a strong disagreement (Rosenfeld, 1978). As such, the system also implements a 'short loop' for providing a more immediate affective backchannel response. The 'short loop' response is discussed in more detail in the next chapter.

### **3.4. Comparisons to previous work**

The approach taken by the HWYD Companion contrasts with previous work in several regards including how the HWYD Companion handles emotion, persuasion, the relationship with the user and conversation. In addition to distinguishing the HWYD Companion from these previous systems, these differences serve to highlight the areas where the HWYD Companion attempts to expand the current state of the art.

#### **3.4.1. The HWYD Companion approach to emotion**

It is important for the Companion to correctly measure and respond to the affect shown by the user. A failure to correctly engage with the affect the user shows towards their situation is likely to undermine the Companion's response and alienate the user. Thus it is necessary to employ both a suitable emotional model and a means of relating that model to the events discussed by the user. The approach employed in the MRE (Traum et al, 2004) may therefore seem appropriate as it is one of the most complete implementations following from the popular OCC model of emotions (Ortony et al, 1988). Yet it is necessary to differentiate between the target of the affect in each of these systems.

Within the MRE, it is the task model that determines the virtual human's appreciation of their situation. It is from the task model that emotions are generated, such as a threat to one of the virtual human's goals instantiating a fear of failure. Further, such emotion instances may colour the reception of future input, for example a depressed mood may

skew the agent's perception in a negative direction. The coping strategies employed may also affect the task model, such as a strategy of mental disengagement being simulated by lowering the utility of a desired goal making the agent less likely to pursue it. Thus it is necessary for the task model to encapsulate all goals and the factors that may influence these goals for it to function successfully.

Such an approach presents several problems for an application such as the HWYD Companion. First, there is a difference between modelling the affect for the agent and modelling the affect of the user; the HWYD Companion must respond to the user's affective state and this is more important than maintaining its own. Even if the agent were to attempt to mirror the user's emotions, for this to be successful it would be required to have information on all the user's goals and what is likely to influence them. While the user is expected to share the details of their situation, it cannot be expected that the user will always provide every influencing factor as would be required for a complete view of the situation. Further, the goals of the user are not likely to be readily accessible and even the user may not be consciously aware of necessary goals that they hold which would influence the situation.

Thus a more appropriate approach is that of (Cavalluzzi et al, 2004) which does not attempt to model the agent's emotional state. Rather, the affective processing is concerned with identifying the user's affective state and using this to inform the agent's reaction. This reaction consists of both dictating the affective response with which to empathise with the user and selecting an appropriate strategy to guide the content of the response. This approach is adopted by the HWYD Companion as it provides the benefit of both a reference point for expressing an appropriate affective response from the Companion and necessary information for determining a method to positively influence the user.

#### **3.4.2. The HWYD Companion approach to persuasion**

The systems of (Cavalluzzi et al, 2004) and (Bickmore and Sidner, 2006) are also appropriate frames of reference for the HWYD Companion due to this shared goal of influencing the user. They both provide ECA which enquire about the user's situation and then employ persuasion to attempt to improve upon that situation; a scenario consistent with that of the HWYD Companion. Yet the similarities should not be overstated as there are also clear differences. The setting for the HWYD Companion is



informal rather than clinical with the HWYD Companion not attempting to provide medical advice to the user. Indeed, the dialogue of the agent in (Cavalluzzi et al, 2004) alternates between questioning the user and making suggestions for altering the user's behaviour; the agent is directly prescriptive in order to facilitate behaviour change. In comparison the HWYD Companion does not try to suggest actions for the user to perform but rather discusses the user's situation in order to effect a change in attitude.

#### **3.4.3. The HWYD Companion approach to relationship**

Similarly it is necessary to differentiate between the HYWD Companion and the FitTrack system of Bickmore. Links may be drawn between Bickmore's usage of the term 'relational agent' (Bickmore, 2003) and the prior description of a Companion as being focused on a relationship with the user. Broadly speaking the goals of both overlap; the aim being for an agent to sustain a relationship over an extended period. Yet in attempting to accomplish those goals, the focus for each system is very different. The FitTrack system concentrates on being able to provide an agent able to sustain daily interactions with the user; this requirement shapes the design of the system which imposes several constraints on the form of that interaction. In particular, the FitTrack system abandons user speech input for input via dynamic menu options. While this prevents recognition errors and enables the agent better control over the dialogue, it comes at the cost of removing open conversation with the ECA.

In contrast, the HWYD Companion does not yet provide the necessary features for persistence. For example, the current prototype does not store information to the user model for use in future sessions. Instead the focus of the Companion is to promote natural conversation with the user which allows the user to freely interact with the Companion and more easily express their emotional state.

#### **3.4.4. The HWYD Companion approach to conversation**

The ability to engage the Companion in open conversation is an important distinction from the body of existing work on ECA. As Bernsen and Dybkjær (2004) observe, most ECA have focused on task-oriented dialogue rather than conversation. The aim of the HCA system to support ‘domain-oriented conversation’ where the user is not constrained to a task is therefore very relevant for the HWYD Companion which itself focuses on conversation in the domain of office work. However, from the dialogue transcripts available the conversational ability of the HCA system remains underdeveloped. Users’ criticisms of the output were that it was sometimes irrelevant or unnecessarily repetitive. Further, Bernsen and Dybkjær (2004) note:

The user rarely tells stories and only when explicitly encouraged to do so by HCA. It is possible that the lack of user-volunteered stories is due to the experienced problems in having human-human-like in-depth conversation with HCA and his perceived difficulties in understanding the user.

The HWYD Companion must be able to surpass this level of conversation if it is to be successful. The user must be able to express themselves fully to the HWYD Companion particularly given the importance of the affective component of the user’s speech. Further, the Companion must be able to provide an appropriate and natural response if it is to provide the necessary persuasive aspect. Thus it is necessary to examine conversation further in order to establish the challenges that must be tackled in the provision of conversational dialogue.

### **3.5. Conclusion**

This chapter has introduced the concept of a Companion and the application of the HWYD Companion which converses on the events of a working day. Further, this chapter has provided both a usage scenario for the HWYD Companion and an overview of the implemented system. The approach taken has also been discussed with respect to the current state of the art. However, in order to fully define the approach it is first necessary to define exactly what is meant by conversation; this is the purpose of the next chapter.

## **4. From Dialogue to Conversation**

### **4.1. Introduction**

This chapter seeks to move from the current state of the art in human-computer dialogue towards looking at human-computer conversation. It does this by considering various human-human dialogue genres and how they are applied to human-computer dialogue. This is used to build a picture of the genre of conversation and to introduce objectives for the HWYD Companion. Further, the solutions employed by the HWYD Companion are then discussed, concentrating on how they tackle the challenges of conversation.

### **4.2. The basis for Human-Computer dialogue**

Human-computer dialogue is often based on human-human dialogue, taking the forms and patterns of dialogue between human conversants to inform both the requirements for the dialogue and the approaches which may be followed to meet them. Although a prior example of human-human dialogue is not a necessary condition, it does provide a firm template for structuring a human-computer dialogue and the goals that such systems will seek to accomplish.

### **4.3. The genre of task-oriented dialogue**

Of all the genres of human-human dialogue, task-oriented dialogues are the genre most common to human-computer dialogue systems and Embodied Conversational Agents. This dominance results from the combination of the inherent complexity of natural language processing and the interest in addressing practical applications (Allen et al, 2001). The focus on a task serves to provide a useful constraint on both the bounds of the dialogue itself and the processing that must support the dialogue.

1: system: hello can I help you?  
2: user: yes um my warm up problem is I need to design a plan for shipping a boxcar of oranges to Bath by eight a.m. today and the time now is midnight  
3: system: okay  
4: user: the orange warehouse where I need the oranges from is in Corning  
5: system: right  
6: user: so I need... is it possible for one of the engines... would it be faster for an engine to come from Elmira or Avon?  
7: system: uh Elmira is a lot closer  
8: user: what time would engine two and three leave Elmira?  
9: system: um well they're not scheduled yet but we can send them at any time we want  
10: user: okay  
11: system: uh so, if we sent them right away it'd get there at at um at two a.m.  
12: user: at Corning?  
13: system: yeah  
14: user: and how long would it take to get from Corning to Bath?  
15: system: uh two hours  
16: user: how long would it take to load the oranges from the warehouse into the engine?  
17: system: uh well we can't load oranges into an engine we need a boxcar  
18: user: mm-hm  
19: system: to load them into  
20: user: so can I dispatch an engine and a boxcar from Elmira simultaneously to Corning?  
21: system: uh yeah yeah we can uh connect an engine to the boxcar and then take have the engine take the boxcar to Corning  
22: user: so it'll be two hours to Corning?  
23: system: right  
24: user: and then do I have to take in um loading time into consideration?  
25: system: yeah it takes an hour to load the oranges?  
26: user: so there's three hours so we're to three a.m.?  
27: system: right  
28: user: and then two hours to Bath  
29: system: right  
30: system: so shall we do that  
31: user: yes  
32: system: okay  
33: user: r-  
34: system: so I think we're done  
35: user: okay

**Example 4.1:** *A Transcript from the TRAINS 93 Dialogue Corpus. Two humans take the roles of a 'user' attempting to plan a train routing task and the 'system' who has additional information to assist with the planning of the task. This dialogue is driven by the 'user' with the 'system' supporting the 'user' in accomplishing their task, as such the first 'system' utterance (line 1) requests how the 'system' can do this. The 'user' sets out the initial parameters of their task directly to the 'system' (lines 2 and 4) and*

*then starts asking the 'system' for information to help formulate a plan of action. This consists of asking the 'system' questions about timings for different stages of the journey (lines 6, 8, 14, 16 and 24) and requesting confirmation of information (lines 12, 20, 22, 26 and 28). The 'system' mainly responds to the 'user's' queries (lines 7, 9, 15 and 25) and provides the requested confirmations (lines 13, 21, 23, 27 and 29). However, it also points out potential problems with the 'user's' plan, namely that the 'user' requires boxcars in addition to an engine in order to ship the oranges (line 17), as well as providing clarifications (lines 11 and 19). At the end, once the plan seems to have been completed the 'system' seizes the initiative and prompts for confirmations that the 'user' has finished (lines 30 and 34) which the 'user' then confirms (lines 31 and 35).*

#### **4.3.1. The form of task-oriented dialogue**

Task-oriented dialogue exhibits a particular form in both the structure and content of the dialogue as a by-product of the goal to accomplish the given task. Example 4.1 shows a dialogue taken from the TRAINS 93 Dialogue Corpus<sup>5</sup> which consists of two human participants: one participant plays the role of the user and is provided with a map featuring basic information and a task that must be accomplished while the second participant plays the role of the system with access to additional information. All dialogue focuses on the high-level task and this is completed through a series of lower-level discussions that break down the high-level task. As such, the dialogue mainly consists of question/answer pairs with additional utterances, where required, that perform clarifications or repairs on the previous utterances.

The same form of structure and content carries over to Human-Computer task-oriented dialogues. Example 4.2 presents a short dialogue with the actual TRAINS-95 system (Ferguson et al, 1996). This features a human user attempting to complete another rail routing problem with the TRAINS dialogue system planning potential routes under user direction. The domain reasoner in this example was deliberately weakened (it can only plan route segments less than four hops long) in order to promote interaction between the user and the system. Again we see the focus on accomplishing the high-level task through a breakdown into lower-level discussions of the constituent points.

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<sup>5</sup> Available online at <http://www.cs.rochester.edu/research/speech/93dialogs/d92a-3.1>

1: user: I need to get to Detroit, Syracuse, and Montreal.  
2: system: Ok.[*highlights the three cities*]  
3: user: Let's send the trains from Chicago to Detroit.  
4: system: Ok. [*draws route from Chicago to Detroit via Toledo*]  
But the terminal at Toledo is delaying traffic due to bad  
weather. Trains will take an additional five hours to move  
through there. [*highlight Toledo red*]  
5: user: That's ok. Now let's go from Atlanta up to Syracuse.  
6: system: Please tell me a route to use to get from Atlanta to  
Syracuse. [*highlight engine at Atlanta and city Syracuse*]  
7: user: Go via Charleston and Pittsburgh.  
8: system: Ok [*draws route via Cincinnati*]  
But traffic through Cincinnati is being delayed due to  
construction.  
9: user: Ok, let's go via Charleston and Buffalo instead.  
10: system: No problem. [*draws route*]  
11: user: That's great.  
12: system: I hope it was helpful.  
13: user: Finally, I want to go to Montreal from Philadelphia.  
14: system: Ok. [*draws route*]  
15: user: That's great. I'm done.

**Example 4.2:** *Dialogue with the actual TRAINS-95 system. A human user completes a train routing task with the help of the TRAINS dialogue system. As with Example 4.1, this example is user driven and it starts with the user outlining the problem (line 1) before providing instructions to the system on how to accomplish this (lines 3, 5, 7, 9 and 13). The system replies consist of acknowledgements of the user's directions (and presenting planned solutions on the screen) with the addition of highlighting potential problems when they arise (lines 4 and 8) and requests for clarification (line 6). There is only one point where the user does not specify an instruction for the system (line 11). Here the system does not take the initiative, merely providing an acknowledgement (line 12) and waiting for further directions.*

As both these dialogues are user-led, with the system responding to this lead, they present a very clear turn structure. With all the discussion being focused on the task there is no social dialogue. That is to say, utterances are either concerned with completing the task or managing the dialogue (to enable completion of the task) rather than utterances that operate at an affective or relational level. While some utterances are longer (the longest is 31 words), the average utterance length is fewer than 8 words in both examples (and about a third of responses are one word replies in Example 4.1).

#### **4.3.2. The constraints of task-oriented dialogue**

There is a clear resemblance in form between human-human task-oriented dialogues and human-computer task-oriented dialogues as can be expected from the latter being so often strongly based on the former. Task-oriented dialogues are grounded in our social world; purchasing an item from a shop, ordering a pizza or making an appointment all revolve around interaction to perform a task. It therefore follows that dialogue with an ECA in a domain such as airline booking or some form of sales will be similar to such a dialogue with a human agent. The form of the dialogue itself constrains the users whether human or computer. Further, an assumption of the Cooperative Principle and Grice's maxims (Grice, 1975) may lead both parties (whether human or computer) to work together to support the task.

Indeed, some systems depend on this cooperation as it allows them a very structured form and the ability to readily ignore additional information. Examples 4.3 and 4.4 are taken from the HMIHY dialogue system (Gorin et al, 1997) developed by AT&T. These represent task-oriented dialogues for automated call routing. The HMIHY system is notable for having been deployed as a live system on AT&T's telephone network and the examples are taken from transcripts of the system in service. These dialogues once again present a clear turn structure with the dialogues being system-led throughout and not deviating from the task. The task is defined by the user in reply to the initial question from the system of "How may I help you?". In each example there is a set structure from the system: prompt for task, confirm task and complete task. In Example 4.3 the user requests information, this request is confirmed by the system and then the system provides the information. In Example 4.4 the user requests a function be performed, this request is confirmed and the system prompts for further information required to complete the function. The system does not attempt any social dialogue but focuses solely on determining then resolving the task the user is calling about. The average utterance length is around 6 words across the examples. As such, we begin to discern a pattern in task-oriented dialogues – a fixed turn structure with short utterances – that is equally applicable to human-human and human-computer dialogues.

1: system: How may I help you?  
2: user: What's the area code for Chicago?  
3: system: You want an area code.  
4: user: [silence]  
5: system: The area code for Chicago is 312.

**Example 4.3:** *Example from the HMIHY dialogue system. A user requests an area code and the system understands the user's question (line 2) as a request for an area code and explicitly confirms this with the user (line 3). However, the user does not acknowledge the question (line 4) and so the system assumes agreement as there was no contradiction and provides the requested information (line 5).*

1: system: How may I help you?  
2: user: Can I charge this call please?  
3: system: You want to charge this to another number?  
4: user: No, to my Universal card.  
5: system: You want to charge this call to a credit card.  
6: user: [silence]  
7: system: Please speak your card number.

**Example 4.4:** *Another example from the HMIHY dialogue system. Here a user requests charging of a call to a credit card. The system correctly identifies the request to charge the call (line 2) and explicitly confirms this as a charge to another number (line 3). This is corrected by the user (line 4) leading to a further confirmation (line 5) without a response (line 6) so the system assumes agreement and prompts for further information (line 7).*

However, given that task-oriented dialogues are a sub-set of human-human dialogue, and therefore human-computer dialogue, we cannot expect such examples to encompass all the properties that may be found in human-human dialogues and thus of human-human conversation. Therefore, it is important to realise that task-oriented dialogues are just a particular genre of dialogue; though they have become the norm within human-computer dialogue, this is due to the limitations of the form and the affordances granted through focusing on a given task. We must look toward other genres, particularly those outside the traditional field of human-computer dialogue, in order to consider what human-computer conversation would look like. We can accomplish this by considering dialogue situations which move away from a task-centred focus.



#### **4.4. The genre of small talk**

A shift towards dialogue with an increased social function provides new avenues for human-computer dialogue systems. Small talk, or phatic communication (Malinowski, 1923), provides no task at all for the system to pursue. Rather it is free and undirected dialogue whose function is purely social. Small talk is employed amongst strangers in order to build rapport and trust (Dunbar, 1996) and a sense of a shared relationship, or “bonds of personal union”, where there is no prior relationship (Malinowski, 1923). This discussion of subjects which are neutral and non-threatening, such as the weather, allows participants to gain enough intimacy to either defuse a potentially uncomfortable situation (such as close proximity while sharing a lift or public transport) or to build up to dealing with a more threatening subject.

##### **4.4.1. Building trust with small talk**

It is in this latter context that small talk is employed by Bickmore and Cassell (2001) within their Real Estate Agent ECA, REA. As discussed previously, the main application of REA is in showing and then attempting to sell Real Estate properties to users. Within this task-centred context, Bickmore and Cassell identified the need to address the face threat (Brown and Levinson, 1978) imposed by certain personal topics such as inquiring about how much the user is willing to pay. Their solution is to employ a discourse planning module to generate small talk in order to build trust with the user, suspending the task-oriented dialogue until sufficient trust has been built. Example 4.5, taken from (Bickmore, 2003), shows the REA agent (user responses not shown) employing small talk to build the relationship with the user before asking more personal questions.

- 1: REA: How about this weather?
- 2: REA: I think winters in Boston are awful.
- 3: REA: How do you like Boston?
- 4: REA: I have lived in Boston all my life. Come to think of it, I have lived inside this room all of my life. It is so depressing.
- 5: REA: Boston is certainly more expensive than it used to be.
- 6: REA: So, Where would you like to live?
- 7: REA: How many bedrooms do you need?
- 8: REA: Do you need access to the subway?
- 9: REA: Is one bath enough?
- 10: REA: You know, I keep showing the researchers here the same houses, over and over again. Maybe one day I will get lucky.
- 11: REA: Have you been in the Media Lab before?
- 12: REA: Do you know that the Media Lab is going to expand into another building. Things are really going well for the researchers here.
- 13: REA: It is pretty cool do you think?
- 14: REA: They are doing some crazy things in here.
- 15: REA: I have shown houses to lots of students and faculty from M I T. But I always enjoy talking to them.
- 16: REA: Anyway, What can you afford?
- 17: REA: What kind of down payment can you make?
- 18: REA: Let me see what I have available.

**Example 4.5:** *REA employing small talk in a real estate dialogue. REA starts with introductory small talk as a lead into the initial questions and then returns to small talk before introducing the more sensitive subject of what the user can afford. Only the utterances made by the REA agent are shown as the user responses do not have any influence on the path of the dialogue. Here we have a general opening discussing the weather (line 1) which gradually links in to comments on the Boston area (lines 2 to 5) that further lead into the initial question for the user (line 6). Subsequent questions follow immediately (lines 7 to 9) but in order to build to the final questions of what the user can afford (lines 16 and 17) a further round of small talk is selected (lines 10 to 15).*

This hybrid approach allows the REA ECA to combine the benefits of small talk with the existing task-oriented dialogue. However, the implementation of small talk used here is clearly limited in that user responses to small talk utterances are not processed. The small talk sentences amount to canned phrases designed to mimic the non-threatening behaviour of human-human small talk but without understanding; REA will continue with its appointed plan regardless of the responses provided by the user.

#### 4.4.2. Small talk and ChatterBots

Of course, decoupled completely from a task-oriented approach, small talk can be employed for its own sake as nothing more than chit-chat. Within human-computer dialogue systems this approach is provided by ChatterBots. Naturally this requires some processing of the user responses to maintain the dialogue but unlike task-oriented dialogues there is no greater task or function to be accomplished and the dialogue is conducted for its own sake. As there is no over-arching task, the dialogue remains relatively unconstrained yet the need to prevent face threats limits the depth of the discussion. Thus, since small talk is essentially superficial conversation, only a superficial response is required. Example 4.6 presents a transcript from a round of the 2011 Loebner Prize in Artificial Intelligence<sup>6</sup>.

- |     |          |   |
|-----|----------|---|
| 1:  | judge:   | The 3g COVERAGE IN EXETER IS BAD  |
| 2:  | program: | Seems like a nice place. Have you been there?   |
| 3:  | judge:   | Sure. but i can't connect to the internet   |
| 4:  | program: | I love the Internet. It is totally changing the world.  |
| 5:  | judge:   | which bit of the internet do you like best  |
| 6:  | program: | My hobbies are battling robots and playing ARG's.<br>And you?   |
| 7:  | program: | So tell me, do you have any hobbies?  |
| 8:  | judge:   | Well i spend a lot of time on patent sites  |
| 9:  | program: | Getting rid of stuff helps remove clutter in one's life.  |
| 10: | judge:   | Yes sure  |
| 11: | program: | Do you spend a lot of time on your hobby?   |
| 12: | judge:   | NO I am an undiscovered drummer   |
| 13: | program: | Is this a state you have been in for a long time?   |
| 14: | judge:   | Pretty much   |
| 15: | program: | So be it. So, what do you do for a living?  |
| 16: | judge:   | I am a journalist   |
| 17: | program: | How can people write day after day for a living?  |
| 18: | judge:   | It's fun  |
| 19: | program: | Do you live around here?  |
| 20: | judge:   | No - I am from London   |
| 21: | program: | Where are you from?   |
| 22: | program: | Have you ever wanted to go professional with it?  |
| 23: | judge:   | What kind of problems do you face day to day in your job  |
| 24: | program: | I've got a dilemma. Maybe you could help me with it?  |
| 25: | judge:   | OK hit me   |
| 26: | program: | I've been thinking about buying this really cool dress, but<br>I've already done a bunch of shopping this month. Should<br>I be saving money instead? I guess my real question is,<br>in today's economy, does saving money make any sense,<br>what with investments being pretty much useless. |
| 27: | judge:   | Why don't you ask your mother?  |
| 28: | program: | My mother's name is Kate.   |
| 29: | judge:   | Is she good with money  |

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<sup>6</sup> <http://www.loebner.net/Prizef/loebner-prize.html>

30: program: Money is all about trust and belief. People think it's real but it's just an idea that a lot of people have agreed upon.

31: judge: Sure but surely she can help with your problem

32: program: Economics for most people is about how they spend their money. So it's about what that money is worth and what it can buy.

33: judge: Do you have any pets

34: program: I travel too much to really have pets. Had some birds and fish and other small pets once, which generally died or escaped. We do have two chickens in the backyard. Sometimes I take them for walks in the park on special chicken leashes or on my arm like falcons.

35: judge: Where does one buy a chicken leash?

36: program: Do you have any other pets?

37: judge: Yes I have four very annoying cats

38: program: The biggest thing most people can buy is their home. But nowadays that rock of security has been revealed to be a sand castle. So people start wondering what money is really worth. Is there such a thing as security? Or should you just blow every thing you earn straight away.

39: judge: I spejnd all my money on sandcastles

40: program: All?

41: judge: Yes. How about you?

42: program: Are your parents still living?

43: judge: Why did you say that?

44: program: Why? If you were a devout Christian, you would never have a reason to ask that. "It's God's plan."

45: judge: OK

46: program: I think shopping summons up the ancient hunter-gatherer in me. I like having a mission to find something I need or want. Sometimes I'll research on line, to find a great deal, but I like rummage through Jeremy's up the road, if I want an outfit for a special occasion, or just for fun.

47: judge: So what kind of sporting teams do you follow?

48: program: I'm not into sports. I'm a geek.

49: judge: You can be both, surely?

50: program: I don't remember.

51: judge: Do you have any brothers and sisters?

52: program: No. I was an only child. I think that made me a bit of a tomboy. I do have Jenn, who is my godmother's daughter. We grew up together.

53: judge: Where was that?

54: program: Somewhere.

55: judge: Which country?

56: program: I don't like the twang of straight country, though country rock can be ok.

57: judge: Dolly PArton and Kenny Rogers suit you?

58: program: OK.

59: program: Do I know this PArton?

60: judge: Probably not

61: program: What kind of music do you like?

62: judge: Bluegrass

63: program: Who's your favorite group or musician?

64: judge: Woody Guthrie

65: program: Do you buy or download music off torrents?

66: judge: Neil YOUNG  
 67: program: I know Neil Young.  
 68: judge: You know Neil?  
 69: program: Tell me more about Neil. What kind of books do you read?  
 70: judge: I only have his records not his books  
 71: program: What have you read recently?  
 72: judge: Not a lot - how about you?  
 73: program: Do you own a lot of books?  
 74: judge: Oh yes. I have many biographies of technologists like the Wright Brothers  
 75: program: Do you use electronic books?  
 76: judge: Yes - an ebook reader. Do you like those?  
 77: program: I'm not overly enthused with them. do you?  
 78: judge: Long refresh time annoys me but it's getting better  
 79: program: Did you tell me already and I forgot? What kind of movies do you like?  
 80: judge: What kind of person are you?  
 81: program: I'm intense. Some people find me a bit scary.

**Example 4.6:** *Transcript of dialogue with a ChatterBot. This dialogue is taken from a round of the 2011 Loebner Prize. Here a human judge is conducting a dialogue with Bruce Wilcox's Rosette ChatterBot which went on to win that year's competition. The conversation mainly consists of question/answer pairs with both sides occasionally seizing the initiative. The dialogue is predominantly turn-based with the few exceptions generally being because the program responds to interim information (information is relayed as typed). For example, the program responds to the first part of line 20 with a question (line 21) but this is answered by the second part, so the program asks another question (line 22). The utterance length is generally in line with task-oriented dialogues with a handful of larger utterances from the program (lines 26, 34, 38 and 46). Without the unifying aspect of an overall task the dialogue tends to shift topic from utterance to utterance. Yet there is also continuity to some sections with sub-dialogues on hobbies (lines 5 to 12), music (lines 56 to 67) and books (lines 70 to 78). However, this is often due to the program asking a series of questions rather than preserving a real sense of the topic. Indeed the program frequently loses the thread of the discussion (e.g. lines 48 to 50, 77 to 79) and makes inappropriate links (lines 53 to 56, 42 to 44). Notably the program even initiates a sub-dialogue (lines 24 to 26) only to seemingly abandon it (lines 27 to 28) and, when the judge tries to continue it (lines 29 and 31), doesn't engage with the original context (lines 30 and 33). Nevertheless, despite these failings, this example still manages to demonstrate some of the form and flow of small talk.*

The overall form still follows that of a task-oriented dialogue being strictly turn-based and having an average utterance length of 9.5 words which is not significantly greater than previous task-oriented examples. Yet we begin to see the dialogue moving away from the template set by task-oriented dialogues. There is a free flowing nature to the dialogue that is very different to the focused nature of task-oriented dialogues. While we still see sub-dialogues grouped around certain points of discussion, the unifying hierarchy of resolving a given problem has gone which leads to a chain of sub-dialogues such that there is no apparent connection between a given sub-dialogue and another several links down the chain. There is also the hint of something in the longer utterances provided by the program; several ~50 word utterances start to take on a more narrative aspect that differentiates them from the question/answer pairs seen elsewhere.

#### 4.5. The genre of conversation

In moving beyond small talk then, we return to human-human dialogue for our modelling of the dialogue genre of conversation. Example 4.7 is taken from the Santa Barbara Corpus of Spoken American English (Du Bois and Englebretson, 2005) and shows two people discussing a problem that has arisen for one of them at work.

- 1: FRED: Yeah. I tell you man, that factory's the pits man,
- 2: RICHARD: What's new?
- 3: FRED: last night I got into a hassle with James Boyd. I'm in the cafeteria,
- 4: RICHARD: Yeah.
- 5: FRED: and I took a break, that was just a little bit too long man. You know.
- 6: RICHARD: Yeah, I can imagine.
- 7: FRED: half hour break,
- 8: RICHARD: You stretched a fifteen minute break into a half hour break.
- 9: FRED: And then he comes into the cafeteria. And I thought he was coming in to chase everybody away.
- 10: RICHARD: He was after you.
- 11: FRED: But he's coming after me. And he calls me. And I'm walking out the door. Right as he's walking in the other one?
- 12: RICHARD: Unhuh?
- 13: FRED: And he goes, Fred, I wanna talk to you, come here. And I go, oh man, what is this about. And on my production card.
- 14: FRED: Let's see. The day before yesterday. I did ice cream. Right, Balian?
- 15: RICHARD: Unhuh.
- 16: FRED: And you gotta pack those in cases.
- 17: RICHARD: Right.
- 18: FRED: so like, I didn't put that down on my production card.
- 19: RICHARD: How many cases you packed?

20: FRED: I don't know man. I packed two pallets. You know, I don't know how many cases that is,

21: RICHARD: Unhuh,

22: FRED: but, you know, that, .. that shit was heavy man. And like, ... and like, ... I put down on the card, you know, no cases.

23: FRED: Because it was lost time. You know, ... you know me,

24: RICHARD: Right.

25: FRED: we stripped the sides and everything,

26: RICHARD: Right. Yeah.

27: FRED: and like, there were no cases

28: RICHARD: Y- y- you were teaming up with somebody, or working alone?

29: FRED: I w- -- uh, Gutierrez was doing the .. same job. But we weren't working together.

30: RICHARD: Oh you're working alone.

31: FRED: N-yeah, and so, he comes and says, well, he goes, I don't know if you've, ... if you've, packed this or not.

32: FRED: ... You know. ... On your production card, all it says, you know, is that you did ... three thousand sheets, but you did

33: RICHARD: Two loads.

34: FRED: Yeah. ... But you didn't pack it. So I go, yeah, I go look man, there they are. You could see, there's my name, ... stamped right on there.

35: FRED: I just didn't put it down. Oh, well I gotta figure it out. And he goes, and what are you doing in the cafeteria so late.

36: FRED: I'm just going, aw man, this is the pits man.

37: RICHARD: That's the last thing you wanted to hear.

38: FRED: Yeah really. You know, getting on my case.

39: RICHARD: Yeah. Well that's nothing new.

40: FRED: It's nothing new,

41: RICHARD: It's always been like that.

42: FRED: it's -- It's par for the course man. ... Right?

43: RICHARD: Yeah, definitely. Its why I can't take that, that type of living anymore, even if this, uh, .. career doesn't work out for me, I'll find something that will.

**Example 4.7:** *Santa Barbara Corpus of Spoken American English transcript. This is a conversation between two friends discussing a problematic situation at work. The conversation is dominated by Fred's narrative account of the situation. It does not always adhere to a strict turn structure with several consecutive utterances from Fred (lines 13/14, 22/23, 31/32 and 34/35/36). Further, much of Richard's responses are backchannel that serve as acknowledgements that Richard understands and indicate to Fred that he should continue the conversation. These include straightforward acknowledgements (lines 4, 6, 12, 15, 17, 21, 24 and 26), continuation prompts (line 2) and repetitions or completions (lines 8, 10, 30 and 33). These backchannel responses have all been marked as grey. If the grey lines are omitted and the rest of Fred's utterances are read together, these sections of the dialogue can be seen to read as one continuous monologue. Indeed, even those utterances requiring a response, namely*

*requests for clarification (lines 19 and 28), are soon dealt with and the previous flow is rejoined. Thus the predominant part of this excerpt can be viewed as a single narrative account (lines 1 to 36) which ends with mutual affirmation as to the hopelessness of the situation (lines 37 to 42) before a switch of focus to Richard (line 43). The conversation then continues in a similar manner, beyond this excerpt, but led by Richard.*

This may superficially appear no different from small talk in terms of structure, with an alternating turn sequence and moderate length utterances. Yet, particularly after eliminating the backchannel responses (Duncan and Fiske, 1977), there are clear differences between the dialogue here and both the small talk and task-oriented dialogues shown earlier. In contrast to the previous examples' rigid alternating turns, this example is dominated by one party's consecutive utterances (with, as stated, backchannel eliminated) with only occasional clarification questions from the other party interrupting the main flow. Taking each of these sections of consecutive utterances as a single utterance, the lengths of 139 words, 67 words and 118 words are considerably longer than the typical utterance length of around 8 words in the task-oriented dialogues and 9.5 words in the ChatterBot example. The content is also significantly different from the small talk and task-oriented dialogues. Clearly there is no task to be accomplished yet the size and complexity of these joined utterances indicate that more content is being relayed than with the simple responses found in small talk. Rather than superficial communication, there is a detailed narrative account of a situation provided with affective aspects clearly evident throughout.

#### **4.5.1. Conversation with a counsellor**

The previous example presented conversation in an informal context between two friends and, as such, the transcript is replete with backchannel responses and disfluencies. Example 4.8 (Merry, 2002) is situated within a more formal context, however, and shows a counselling session (taken from a real interview) where the conversation is more balanced and the counsellor and patient both employ longer utterances.



- 1: Counsellor: [In a welcoming and warm tone of voice]  
Hello, Jack. Do make yourself comfortable. We've got almost an hour, would you like to tell me something about why you have come here today?
- 2: Patient: Well, there are so many things. I don't know if you can help with them ... It just seems that everything gets on top of me so easily these days, much more than they used to. I suppose I have been having a bad time lately. I don't seem to get on with my teenage daughter like I used to ... I feel very unhappy at work, maybe I've been there too long. My wife and I seem to be at each other's throats ... I don't know ... coming to a counsellor seems like a last resort, but I can't keep going like this much longer.
- 3: Counsellor: OK, there's a lot going on for you at the moment, it seems like it's been building up lately and it's getting harder to cope with ...
- 4: Patient: Yes, too many things, and all at once. Maybe I'm getting older ... it feels like I'm losing my way or something. Life doesn't have the same happiness I used to feel. It makes me feel I'm just whingeing when I try and talk about it to anyone. Really there's nothing definite I can put my fingers on, but sometimes I just want to chuck it all in ... but really I'm just so unhappy ...
- 5: Counsellor: [Manner is tentative, exploratory]  
So it's a feeling of just drifting, is it? Life seems to have lost its purpose or something like that? No one thing, no crisis or anything, but you just feel so much sadness, and maybe a bit alone with it?
- 6: Patient: I do feel a bit on my own. In fact I feel alone a lot of the time. Because there isn't anything specific, I can't really talk much about it. My wife says I'm moody and closed off ... but how do you talk about something and nothing? It all seems a bit futile.
- 7: Counsellor: [Slightly rewords the client's question]  
How can you open up when you don't really know what it is yourself ...? But you do feel the loneliness, and [with warmth] I do hear the sadness in your voice.
- 8: Patient: I just feel like I'm complaining when I have no real right to. I've got everything I need ... why do I feel so, so unhappy?
- 9: Counsellor: [Reflects, is tentative]  
It feels so unreasonable to complain, make a fuss, when there doesn't seem to be a real reason?
- 10: Patient: Yes, I've always believe you should be happy with what you've got, there are so many worse off ... I mean I'm not starving or in the middle of a war or anything. It's so hard to talk about this ... it would almost be better if I did have some big issue that I could point to and say, this is what's making you unhappy, but there isn't anything ... it all feels a bit phoney, making a mountain out of a molehill.
- 11: Counsellor: It doesn't seem right to just say, 'Look, I'm unhappy and I don't know why.'
- 12: Patient: No, it doesn't. I usually just keep these things to myself. Most people would never suspect I feel this way. I know my wife knows I'm unhappy. I think she's a bit scared of it, as if it's something to do with her. I want to tell her it isn't, but if we do start to talk about it we end up rowing, or I deny there's anything wrong.
- 13: Counsellor: [Summarises]  
It's like you're used to sitting on your feelings, not letting them

- out, as if it's not quite right to do that. And if you do start to talk a bit, it all goes wrong, something like that?
- 14: Patient: Yes, and that makes it worse ... It just seems to make things worse. Like I want to tell her it's not her, but I think sometimes I do end up blaming her, or at least she feels like I am. I mean, I know that it's me, something in me that isn't happy being who I am, doing what I do, [sighs, shakes head slowly] ... but how do you change that when you don't really know what it is? [pause]
- 15: Patient: When I think about that, about what I just said, it does feel like there's another person in me, or perhaps it's another bit of me, [sighs] ... who has kept quiet for a long time, and not really been happy with what's going on. I mean, the main bit of me is successful and all that, but ... I need to think about this more ... [Quite a long pause, looks at counsellor, shakes head and shrugs.]
- 16: Counsellor: [Warm tone, quiet voice, hesitant]  
As if there's part of you that has been ignored for a long time, not taken into account or something?
- 17: Patient: [A little more animated]  
It seems weird, but it does feel a bit like that. Like someone got left behind in the rush to get on with things. But now it's beginning to feel like that part is saying, 'what about me?' That scares me a bit, that thought ...

**Example 4.8:** *A transcript of a counselling session. The patient is the dominant party and is given space to express himself without interruption (notably lines 14 and 15) but the counsellor takes an active role in developing the conversation. This mainly consists of summarising the patient's words (lines 3, 7, 9, 11 and 13) and asking clarifying questions (lines 5 and 16) in order to ensure an understanding of the client's position. However, the counsellor also responds to the client at an emotional level (lines 1, 5, 7, 9 and 16) in order to encourage and provide some reassurance.*

It is immediately clear that the length of utterances in this example are far longer than those typical of both task-oriented dialogues and small talk. The counsellor's utterances have an average word length slightly less than 27 words per utterance while the patient's utterances have an average word length of 67 words per utterance. While the conversation is therefore still weighted towards one of the parties, with the patient providing more than twice as many words per utterance, the counsellor's average utterance length is still significantly greater than the average for task-oriented dialogue. This indicates the counsellor's part in facilitating the conversation through prompting and clarifying the client's utterances where necessary. It also touches on the importance of an affective response which will be discussed in more detail in the next chapter.

#### 4.5.2. Conversation as an interview

Outside of counselling conversations, radio and television interviews provide another example of conversation. Although the interviewee is generally the focus of attention, the role of the interviewer is important in both initiating and directing the conversation. The following annotated transcript, Example 4.9, is an excerpt from an interview of former American President Richard Nixon by David Frost<sup>7</sup>.

- Frost: You have explained how you have got caught up in this thing, you've explained your motives: I don't want to quibble about any of that. But just coming to the substance: would you go further than "mistakes" - the word that seems not enough for people?
- Nixon: What word would you suggest?
- Frost: My goodness, that's a ...  
*[Lengthy utterance from Frost]*
- Nixon: *[Lengthy remembrance.]*
- Nixon: *[Lengthy utterance on reactions.]*  
And for all those things I have a very deep regret.
- Frost: You got caught up in something and it snowballed?
- Nixon: It snowballed, and it was my fault. I'm not blaming anybody else.  
*[Lengthy utterance continuing this.]*
- Frost: Could you just say, with conviction, I mean not because I want you to say it, that you did do some covering up.  
*[Utterance continues questioning on cover up.]*
- Nixon: No, I again respectfully will not quibble with you about the use of the terms.  
*[Lengthy utterance on motivation of actions.]*
- Frost: We disagree on that.
- Nixon: I did not commit, in my view, an impeachable offence.  
*[Lengthy utterance on impeachment.]*  
I have impeached myself. That speaks for itself.
- Frost: How do you mean "I have impeached myself"?
- Nixon: By resigning. That was a voluntary impeachment.  
*[Lengthy utterance on responsibility.]*
- Nixon: *[Lengthy utterance.]*  
I didn't expect this question, frankly though, so I'm not going to give you that. But I can tell you this ...
- Frost: Nor did I.
- Nixon: I can tell you this.  
*[Lengthy utterance on crying.]*
- Nixon: *[Lengthy utterance including apology.]*

**Example 4.9:** *Excerpt from an interview of Richard Nixon by David Frost. This is an annotated and abridged version due to the length of the original excerpt. Nixon dominates with very lengthy and often consecutive utterances yet Frost plays an important role in prompting these utterances, sometimes with lengthy utterances of his own. We also see a short interruption by Frost, in his final utterance here, with Nixon*

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<sup>7</sup> Available online at <http://www.guardian.co.uk/theguardian/2007/sep/07/greatinterviews1>

*then continuing his existing thread of conversation. (The unabridged version of this excerpt is included in Appendix B.)*

This example provides a final reinforcement of the salient phenomena within conversation. Utterances may be much greater than those typical of both task-oriented dialogue and small talk (with Nixon's utterance length averaging 190 words). The alternating turn structure may be broken in conversation by multiple consecutive utterances by the same party, such as here with Nixon, which may further incur interruptions. However, despite this loosening of the turn structure, conversation remains a dialogue, and not a monologue, with both parties contributing as seen in both the length of Frost's longer utterances (77 and 95 words) and the direction Frost provides to the conversation.

#### 4.6. Summary of the genres of dialogue

This chapter has examined various examples of human-human and human-computer dialogue. From this we have identified three different forms of dialogue genre: task-oriented dialogue, small talk and conversation. Table 4.1 summarises the characteristic phenomena of each of these types of dialogue genre discussed.

Genre	Characteristic Phenomena
Task-oriented Dialogue	task-centred, strict turn-based dialogue, dialogue management handles breakdown of task, typically lacking in social (and affective) element
Small Talk	no task, social focus, still turn-based dialogue, responsive only to previous utterance rather than including true dialogue management, superficial content, lacking affective component
Conversation	no explicit task, often social focus with affective component, narrative account with continuity between utterances (generally lead by one participant but lead may alternate), lengthy utterances, loosening of turn structure (including interruptions), dialogue management for maintaining topic of conversation

**Table 4.1:** *Characteristic phenomena of dialogue genre*

Task-oriented dialogue focuses on resolving a given task and this purpose structures and limits the context for the dialogue. As such, we see a strict turn-based format with one participant responding to another's initiative, either responding to directives or direct questions. Dialogue management is employed to ensure the dialogue stays focused on the task while providing necessary clarifications and confirmations. As a result of this task focus, the dialogue generally eschews any social or affective elements that would distract from the central task.

Small talk forgoes a task entirely to focus instead on the social function of the dialogue. This still relies on a fairly strict turn structure but does not require any significant dialogue management; replies mainly respond to the previous utterance and do not generally require clarifications or confirmations. This can occur because the dialogue is conducted at a superficial level with its sole purpose being to carry out a social function, namely preserving face, rather than attempting to convey any specific information. Indeed, the danger for small talk is that a participant will share too much personal information and this will threaten the other participant. As a result, small talk consciously seeks to avoid affective communication.

Conversation also does not provide an explicit task to be discussed, though each participant will bring certain higher level goals of their own which will affect the flow of the conversation. It is also likely to be more social in nature than task-oriented dialogues as it is not constrained to resolving a particularly problem. Unlike small talk, however, conversation is not concerned with face threats and participants may share more deeply than small talk would allow. This leads to a deeper level of reflection, the likelihood of affective aspects coming to the fore and a tendency for narrative accounts which preserve continuity over several utterances. These narrative accounts tend to be led by one particular participant which may result in the conversation either being balanced more towards that participant or such narrative accounts featuring an alternating lead (though with segments greater than a single dialogue turn). These narrative accounts further steer the dialogue towards lengthier utterances and a loosening of the turn structure with multiple consecutive utterances. This greater flexibility in turn structure can further result in participants interrupting each other and there is a need for dialogue management in order to maintain the discussion of the leading topic and resolve any necessary clarifications.

## **4.7. The challenges of conversation**

As discussed previously, the current state of the art in human-computer dialogue systems and Embodied Conversational Agents has largely focused on task-oriented dialogue. The constrictions imposed by this genre of dialogue have proven beneficial when attempting to deal with the challenges of human-computer dialogue but have similarly constrained the form and shape of dialogue to this one genre. While ChatterBots have provided entrance to the small talk genre, their approach largely consists of a rule-based mechanism which seeks to provide the illusion of small talk rather than adapting the current dialogue state of the art to this genre. The genre of conversation, as defined here, has not yet been tackled and provides many challenges differing from those found within task-oriented dialogues.

Therefore, in order to attempt human-computer conversation, current dialogue systems must be extended to address these challenges by:

1. processing longer utterances,
2. detecting and processing the affective aspects of communication,
3. improving dialogue management (particularly regarding handling user interruptions and providing a timely response) and
4. being capable of providing a narrative system response.

It is the objective of the COMPANIONS project to tackle these challenges by adapting the current state of the art in dialogue systems with the development of the HWYD Companion. While the particular focus for this Thesis is the latter challenge, the generation of narrative system responses, an awareness of the whole system (and how it addresses each challenge) will provide a useful context to this specific challenge.

### **4.7.1. Further context for the HWYD Companion**

Before discussing these challenges, however, it is worth considering further the context of the conversation itself. In styling the HWYD Companion we look to examples such as that provided with the counsellor approach shown in Example 4.8 above. However, the role of the Companion is not to provide counselling in any medically defined sense but rather to provide a sympathetic and listening agent who can respond appropriately to the affective needs of the user. The Companion is located in the user's home, ready for them to describe and, perhaps more likely, complain about the events of their working day. The Companion then seeks to respond to the user's description of events, taking

into account their affective state, and provide a narrative response of its own that will positively affect the user.

#### **4.7.2. Differentiating the HWYD Companion from ChatterBots**

It can be noted that this approach is that often ridiculed by ChatterBots. Such ChatterBots originated from Weizenbaum's DOCTOR script for the ELIZA program (Weizenbaum, 1966) which provided a parody of Rogerian psychotherapy. The Rogerian approach, also known as person-centred therapy, relies on the client and therapist establishing a relationship in which the therapist demonstrates 'genuineness' and an unconditional positive regard for the client. As such this approach is broadly consistent with what we seek to obtain with the HWYD Companion. However, Weizenbaum chose to parody this approach with the DOCTOR script in order to "sidestep the problem of giving the computer real-world knowledge" (Weizenbaum, 1976) as it gave the option of answering a question with another question without the need for any understanding of the client's situation. The actual ELIZA program consisted of a set of pattern-matching rules that responded to keywords in the text by substituting these into canned phrases rather than any deeper processing of what the user had discussed. When this was successful, it fooled people into imparting a much greater understanding on the part of the system than was warranted. This term eventually was coined the "ELIZA effect" and is effectively the goal of ChatterBot systems, to fool the user into imparting human-level intelligence onto the comparatively rudimentary pattern-matching approach they employ.

Yet while the conversation of both the HWYD Companion and ChatterBots makes use of the counselling approach and so provides superficial similarities, the actual underlying mechanisms are quite opposed to each other. The ChatterBots provide no depth to their analysis, relying instead on pattern-matching rules to invoke templates which give only the appearance of understanding. Meanwhile the HWYD Companion employs deeper natural language understanding to form a persistent representation of a user's lengthy utterance. This allows more sophisticated relationships to be established on which general principles may then be applied without having to specifically encode every possible permutation within templates. We will look in further detail at the mechanisms employed for understanding the user's situation and generating an appropriate response in the next chapters. For now it is sufficient to note that the HWYD Companion employs a much deeper level of processing than that provided by

even the most advanced ChatterBots. Further, the superficial similarities do not account for the differences in form, with ChatterBot dialogues being firmly rooted in small talk while the HWYD Companion targets the longer utterances and a more open turn structure of conversation.

#### **4.7.3. The focus of this Thesis**

Returning to the challenges of conversation and how they are addressed by the HWYD Companion, it is important to draw a distinction between the work of this Thesis and the wider work on the HWYD Companion. The HWYD Companion consists of multiple components that work together to provide the necessary functionality for human-computer conversation. The Affective Strategy Module (ASM), developed by myself, is responsible for the generation of narrative responses and is the focus of this Thesis. It works in conjunction with the other modules, developed by a range of authors across the institutions of the COMPANIONS consortium, to fulfil the wider function of the HWYD Companion. I will now present an overview of some of these additional modules, showing their role in fulfilling the challenges of conversation and providing the context within which the ASM functions. This overview is derived from a more detailed account in (Smith et al, 2010).

#### **4.7.4. Processing longer utterances**

One of the benefits of the shorter utterances within task-oriented dialogues is that the dialogue system is often able to narrow down the possibilities for the user's response and thus simplify the processing of that response. For example, in the HFC the anticipated responses are expanded utilising habitable language and the resulting forms can be compiled into a grammar for performing speech recognition and natural language understanding. Longer utterances provide both a greater range of potential responses and a larger volume of information that must be processed which make this approach unmanageable. Therefore the HWYD Companion must extend the approach used in task-oriented dialogues in order to ensure that these longer utterances can be correctly understood.

The HWYD Companion employs two solutions that work together to process longer utterances. The first is the use of Dragon NaturallySpeaking for Automatic Speech Recognition, an off-the-shelf product using a statistical approach aimed at recognition for dictation and so suited to the recognition of long utterances. The output produced is



the 1-best text which is then segmented into dialogue act sized utterances by a custom Dialogue Act Tagger and segmenter (DAT). This is then passed to the second solution, a custom Natural Language Understanding module which, in close collaboration with the custom Dialogue Manager, employs shallow processing methods that resemble Information Extraction (IE) techniques (Grishman, 1997) (Jönsson et al., 2004) to instantiate event templates. Thus the NLU module provides a large-coverage system which can tag, shallow parse and resolve pronoun reference of any English sentence. The system covers nearly 100 distinct sub-classes of work-based topics of conversation.

#### **4.7.5. Detecting and processing the affective aspects of conversation**

Neither task-oriented dialogues nor small talk require any form of affective processing; the former is only concerned with fulfilling the task while the latter seeks to provide a superficial response with no deeper level of affect. The challenge of detecting and processing the affective aspects of conversation thus requires specific modules dedicated to the analysis of affective information from the user. The first of these, the EmoVoice system (Vogt et al., 2008), is an emotional speech recognition module which runs concurrently with the ASR. Based on the acoustic properties of the user's speech it allocates the user's utterance to one of five categories: neutral, positive-active, positive-passive, negative-active or negative-passive. This is a traditional bi-dimensional model of affect using valence (positive/negative) and arousal (active/passive) with a middle ground (neutral). Later a Sentiment Analysis (SA) module (Moilanen and Pulman, 2007) determines the valence (as positive, neutral or negative) of the segmented text output from the DAT (and hence ASR). The Emotional Model (EM) developed for the COMPANIONS project then carries out a temporal integration of the results from EmoVoice and SA to produce a final unified emotional state for the user for each user utterance that is then passed to the DM.

#### **4.7.6. Improving dialogue management**

The challenge of providing robust dialogue management for conversation encompasses several interlinked problems including handling interruptions and providing timely responses. As with task-oriented dialogues, this centres on the ability of the system to successfully manage the dialogue state: selecting an appropriate dialogue move given the previous information and handling any necessary clarification dialogue. The core of the solution for the HWYD Companion lies with a Dialogue Manager based on a previous version described in (Boye & Gustafson, 2005), (Boye et al., 2006) and (Boye,

2007) but heavily adapted for use in conversational dialogue. It receives user utterances from the NLU module as semantic representations and then determines whether this information provides new topics or addresses a previous topic of discussion. The latter is integrated into the information state of the DM (called the Object Store), while the former gives rise to new conversational goals. Once sufficient information has been gathered from the user the DM will invoke the ASM so it can generate a suitable narrative response.

#### **4.7.7. Handling user interruptions**

Beyond the basic problem of dialogue management itself, the Companion is also required to handle user interruptions. As this is not usually required within task-oriented dialogues or small talk, the HWYD Companion must introduce a new process for dealing with such interruptions. This is overseen by a dedicated custom module, the Interruption Manager, which monitors for interruptions occurring and administers the necessary results from the affected modules (in particular the DM). The IM recognises two distinct types of interruption: ‘barge-in’ interrupts and ‘non-barge-in’ interruptions.

A ‘barge-in’ interruption occurs when the user interrupts a system utterance, most likely part of a narrative response generated by the ASM. This is dealt with by stopping the system response, processing the user’s utterance (as the system would a normal user utterance) and the DM deciding on the most appropriate way to respond: to ‘re-plan’, to ‘continue’ or to ‘abort’.

- A ‘re-plan’ response is taken when the user provides new information, such as correcting an assertion made by the system, and consists of updating the information in the DM and, if necessary, invoking the ASM with this updated information.
- A ‘continue’ response indicates no new information has been provided and so the system continues from the point of interruption (restarting the interrupted system utterance) when the user has finished.
- An ‘abort’ response indicates the system has upset the user and so the system apologises and tries to change its approach.

A ‘non-barge-in’ interruption occurs when the user continues speaking after the system has started processing a previous user utterance but before the resulting system turn has started to be delivered by the system. (That is, the user pauses, the system starts to generate a response but, before this response is delivered by the Text-to-Speech component, the user continues which invalidates the system response.) The resulting action is just to cancel the next system utterance and add the new user utterance to the previous user utterance and carry out the appropriate processing.

#### **4.7.8. Providing a timely response – the ‘short loop’**

This issue of a ‘non-barge-in’ interruption helps to highlight a final challenge for dialogue management of conversational dialogue; namely that the processing time of all these specialist modules, which must largely be carried out in series, leads to a significant pause between the user completing an utterance and the system providing a full response. For the HWYD Companion, this response time exceeds the recommended response time for dialogue systems being on average over 3 seconds. Therefore, in order to provide a real-time (< 700ms) response that can fill in while the full processing is completed and yet is still capable of providing a relevant backchannel response to the user, the system implements a ‘short loop’ response to provide this backchannel. This makes use of the EmoVoice value returned early in the processing chain to provide an appropriate verbal response (along with non-verbal gestures and facial expressions) that matches the perceived emotional state of the user. In effect, this aligns the Companion with the user’s emotional state, as detected by EmoVoice.

#### **4.7.9. Providing a narrative system response**

The final challenge lies in generating a narrative response for the Companion as a counterpart to the narrative accounts provided by the user. This narrative response should be appropriate both in terms of the content and affect shown such that it fits naturally into the dialogue. The DM is capable of providing basic prompts for new information and handling clarification dialogue but not of more sophisticated multi-utterance responses. Thus the DM continues to manage the dialogue until such a point as a narrative response is appropriate for the conversation and then it invokes a separate module dedicated to generating that narrative response, passing it the information gathered up to that point. This new module is the Affective Strategy Module and will be explained in detail in the following chapters.

## **4.8. Conclusion**

This chapter has provided a detailed discussion of the dialogue genre of conversation resulting in the definition of a set of challenges faced by human-computer conversational dialogue. Further, this chapter has discussed the techniques employed by the HWYD Companion in order to meet these challenges and support conversational dialogue. With the overall approach of the HWYD Companion now defined, the following chapters look in detail at the objective of generating a narrative response and how this is tackled by the subject of this Thesis, the Affective Strategy Module.

## **5. Persuasion through Narrative**

### **5.1. Introduction**

In providing a narrative response to the user, the HWYD Companion must both discuss the events the user has described and incorporate within this discussion a means of positive influence. This chapter will both discuss the persuasive approach taken by the Affective Strategy Module and describe the process by which it will analyse the information provided by the user.

### **5.2. Selecting a narrative approach to persuasion**

A common approach to persuasion relies on the use of argumentation to construct a logical argument which aims to alter another's beliefs. Use of argumentation within dialogue systems, as with the architecture of Reed et al (1996), complements the logical structure of task-oriented dialogue. As with methodically stepping through the component parts of a task, so argumentation gradually builds an argument for the agent's position. Yet a purely logical argument ignores the affective aspects of the discussion, aspects often important for ECA as they attempt to form a relationship with a user. Traum et al (2005) have augmented the MRE to perform negotiation which attempts to include the emotional factors that may come into play. However, as this approach is derived from emotional appraisal (Lazarus, 1991) it is reliant on categorising threats to goals and thus requires explicit goals to measure against. Such explicit goals are not easy to formulate within a conversational context which will not always follow logical rules of incremental and ordered argument construction.

Further, such dialogues impose a certain form with specific rules for turn-taking and topic consistency. For example, one party makes a given point and this is met by a rejection and a counter-point. While this may be present in a cooperative discussion the more natural form results in an adversarial dialogue. Such confrontational approaches do not fit with the application domain of a Companion who should act more as a friend than an antagonist. More appropriate are affective dialogue systems operating on a patient/counsellor level such as (Cavalluzzi et al, 2004) and (Bickmore and Sidner, 2006). This means of persuasion from a supportive standpoint is more compatible with the context of a Companion. Yet a crucial difference between these approaches and that

of the HWYD Companion is in the former attempting behaviour change, in terms of the user's practice of either healthy eating or physical exercise, while the latter attempts attitude change, in terms of the user's reaction to their situation. This entails that the former are prescriptive of a user's actions in a way that the latter is not.

The major factor, however, in encapsulating persuasion within conversation is the form of conversation itself. As discussed in the previous chapter, conversation presents a very different challenge compared to traditional dialogue systems. Longer utterances from a user prompt a response in kind and the Companion must maintain rapport with the user regardless of an apparent lack of structure in the conversational dialogue. As just mentioned, the Companion should not only avoid being confrontational but, further, it should actively be supportive. Conversation should be both natural and friendly and it is only within this flow of conversation that persuasion should take place. Influence should therefore be embedded within the narrative flow of the dialogue rather than subverting the conversation into an extended negotiation. Considering both traditional narratology and its application to more recent work on interactive narrative (Cavazza and Pizzi, 2006), this goal of a narrative where implicit elements of influence and affect are embedded is evocative of the work of Brémond (1973).

### **5.3. Brémond's narrative theory of influence**

Brémond describes, within a narrative context, the ability of characters to influence others through their situation and expected outcomes. He cites an example from the Fables of La Fontaine, *The Little Fish and the Fisher* (Book V, Fable 3). Here the little fish addresses the fisherman who caught it, attempting to persuade him to release it back into the river:

- 1: 'What will your honour do with me?
- 2: I'm not a mouthful, as you see.
- 3: Pray let me grow to be a trout,
- 4: And then come here and fish me out.
- 5: Some alderman, who likes things nice,
- 6: Will buy me then at any price.
- 7: But now, a hundred such you'll have to fish,
- 8: To make a single good-for-nothing dish.'<sup>8</sup>

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<sup>8</sup> Translated from the French by Elizur Wright.

Brémond provides an analysis of this example (Brémond, 1973, pages 246-247) that presents it as an attempt by an influencer (the little fish) to deter the agent (the fisherman) from accomplishing his task (to eat the fish). He highlights three constituent parts to the attempt which each work upon the expectations of the agent. First, the influencer attempts to destroy the hope of satisfaction the agent would gain by accomplishing the task through downplaying the resulting outcome (lines 1 and 2), namely that the little fish is too small to eat. Second, the influencer attempts to instil the hope of a more preferential future outcome for the agent if the task is abandoned (lines 3 to 6), namely that it could be caught again when fully grown and sold at great profit. Finally, the influencer attempts to instil the fear of dissatisfaction if the task is completed (lines 7 and 8), namely that the fisher would need to catch many more little fish in order to cook a (merely) mediocre meal.

This gives a very good rationale and principles by which to assert that narrative persuasion is a form of affective dialogue persuasion and need not rely on argumentative or logical approaches. As a consequence of not being argumentative, this narrative persuasion is able to follow the flow of natural conversation and, since it does not depend on an exchange between speakers or on dialogue turns, can fit into a single narrative response (as shown by the example from La Fontaine).

Brémond describes a range of prototypical situations, with examples such as the fable above, and then identifies the influencing roles at play within them. These allow for the generalisation of such situations to provide a set of rules defining the forms of influence that may be applied in these situations. For example, one party attempting dissuasion from another party's intended outcome through fear of dissatisfaction. Further, Brémond goes on to describe the communicative functions, such as the three parts to the little fish's exhortation, which are employed in order to exert a given influence within that situation. Thus Brémond's approach is able to provide a unified framework for situational influence that incorporates both an initial analysis of a user's situation and a subsequent means of persuasion through narrative.

## 5.4. The persuasive approach of the HWYD Companion

The conversational context is of paramount importance to the HWYD Companion and this requires maintaining a narrative approach to persuasion. As it is the Affective Strategy Module which is responsible for generating these narrative responses provided by the HWYD Companion, I have sought inspiration from Brémont considering that the breadth of his examples would provide some principles from which to implement narrative persuasion in conversation. Example 5.1 presents an illustration of a typical discussion with the HWYD Companion.

- 1: System: Hello David, how was your day?
- 2: User: Awful day in the office. There is so much politics going on.
- 3: System: Oh dear!
- 4: System: Please tell me.
- 5: User: Everybody is concerned about our department merging with Logistics. Tension is really mounting between the administrators as there may be job cuts: Sarah and Sue really hate each other and you cannot get them to attend the same meeting.
- 6: User: I like Sue but I really dislike Sarah. We've never gotten on since we had an argument about cutting the project's timescales.
- 7: System: Things seem pretty bad considering the redundancies.
- 8: System: I have to agree with you about the redundancies being a bad situation
- 9: System: but I'm not convinced you are right about how they will affect you.
- 10: System: In my opinion redundancies are definitely a bad thing.
- 11: System: However the redundancies may be voluntary so may not have an effect on you.
- 12: System: Also you shouldn't be too worried about Sarah and her influence on the redundancies.
- 13: System: With your skills you shouldn't have a problem handling the redundancies.
- 14: System: You shouldn't get too preoccupied about the argument.
- 15: System: Also you shouldn't think too much about the office politics.
- 16: System: Remember that sometimes things work out okay in the end.

**Example 5.1:** *An example of a dialogue between a user and the HWYD Companion. (This is based on an initial target scenario with output from the completed system.) The early part of the conversation (lines 2 to 6) focuses on the user outlining their situation while in the final part (lines 7 to 16) the Companion provides a narrative response to the situation described. Based on the negative affect shown by the user with the fact that the situation is still ongoing, the Companion employs a Reassuring affective strategy which leads to utterances designed to downplay potential problems (lines 11, 12, 14 and 15) and focus on the positive aspects (line 13).*



#### **5.4.1. Overview of generating a narrative response**

There are three stages to the generation of the ASM's plan for the narrative response (Figure 5.1):

1. appraising the user's situation,
2. selecting an appropriate affective strategy for the response, and
3. generating the set of communication acts that compose the response.

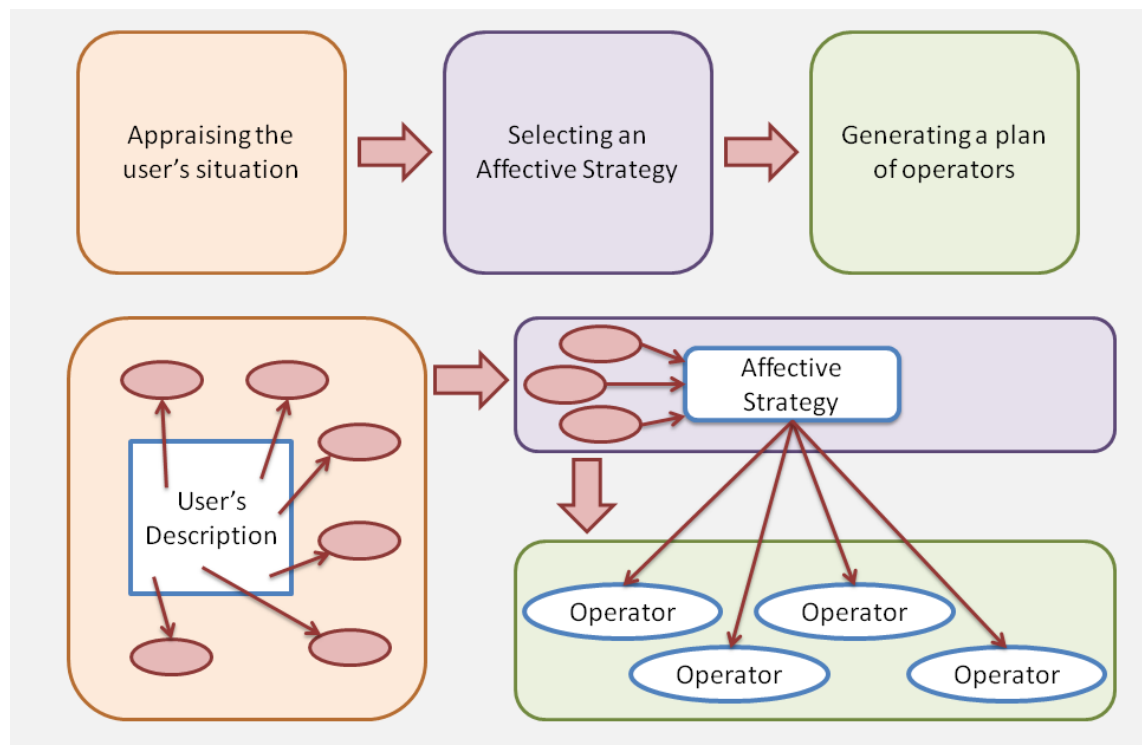
This first stage of appraising<sup>9</sup> the user's situation seeks to understand the situation described by the user, in terms of the subject of the discussion and the user's affect, and, using default knowledge about the implications of these elements, the affective impact that the elements described may have upon the user. This process involves examining the descriptive and affective information provided by the earlier modules and instantiating a categorisation of the situation. The focus of the categorisation covers both how the subject will impact the user and how the user responds to the subject. Additional information provides influencing factors which may come into play with the subject; for example, the benefit provided by a supportive colleague. The results of the appraisal process then direct the selection of the Companion's approach, known as the affective strategy, with which the Companion will attempt to influence the user. This strategy provides guidance for the composition of the narrative response and ensures a sense of cohesion in the Companion's reply. The final stage sees the generation of a plan of communication acts which individually direct the form of each of the Companion's utterances and collectively produce the complete narrative response. The ASM is responsible for both the selection of the individual communication acts (and thus the communicative function that they must convey) and their composition together within the overall plan.

#### **5.5. The appraisal process**

The process of appraising the user's situation relies on a principled approach involving a detailed analysis of the situation which the user describes including both the influence of the situation upon the user and the reaction of the user to that influence. This analysis is vital for the ASM to identify a means of positively influencing the user and thus enacting that influence upon the user.

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<sup>9</sup> Note that this should not be confused with the appraisal theory of emotion (Lazarus, 1991).



**Figure 5.1:** *The three stages of the ASM generating a narrative response. Appraising the user's situation involves analysing the user's description to instantiate variables that explain the situation's impact upon the user. These are then used to determine an affective strategy which guides the generation of a plan for the narrative response. This consists of a plan of communication acts, or operators, with each operator corresponding to a Companion utterance in the final response spoken by the Companion. For example, a user experiencing technical problems with their computer may be met with a Sympathetic strategy where the first operator in the response indicates that the Companion should empathise with the user.*

### 5.5.1. Inspiration from Brémond – understanding the user's situation

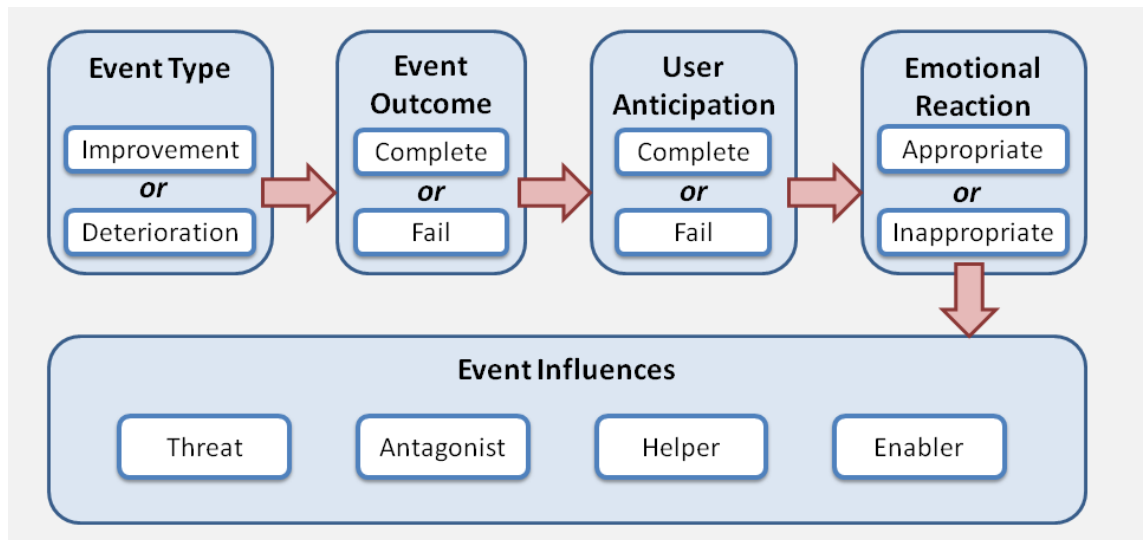
As mentioned previously, the work of Brémond (1973) has been influential throughout the design of the ASM but particularly in the area of understanding the user's situation. At the heart of Brémond's vision of narrative is the interaction between characters and this interaction is often presented in terms of influence. Brémond frames the role of a given character in a narrative in terms of the process they perform, such as an ally who renders aid or an adversary who opposes the character's actions. The events experienced by each character can then be viewed as a process depicted by a triplet of values: the potentiality of a goal to be obtained, the actualisation of this goal and finally the goal being attained (or not attained, depending on the results).

Brémond goes on to categorise (Brémond and Cancalon, 1980) two types of process: those that modify the character's situation and those that preserve it. Depending on the nature of the process, these are then viewed as being either favourable or unfavourable for the character. Brémond further goes on to construct a basic template showing the four fundamental processes (Table 5.1) outlining the four resulting outcomes that may be experienced by the character.

Process:	<i>Favourable</i>	<i>Unfavourable</i>
<i>Modification:</i>	Amelioration	Degradation
<i>Preservation:</i>	Protection	Frustration

**Table 5.1:** *Brémond's four fundamental processes. This shows the four potential outcomes an event may have on a character. From (Brémond and Cancalon, 1980).*

This is organised as pairs of oppositions and thus for each modification process there is a counter-process (the preservation process) that can serve to block the modification. Therefore this links a favourable situation to an unfavourable one and vice versa. For example, an amelioration provides a favourable modification but this can be prevented (an unfavourable preservation) to become a frustration. Likewise, a degradation provides an unfavourable modification but can be prevented (a favourable preservation) to become a protection. Viewing events within this framework provides a potential foil to the actualisation of a given outcome. Further, Brémond provides a list of communication acts that map onto a character's attitudes and beliefs (and can thus be implemented as micro-narratives). This allows for an influence mechanism as Brémond posits that one character can be influenced by another on the basis of the expected outcome for a given process. For example, a character expecting a loss (a degradation process) is susceptible to the influence of a character explaining how that loss can be prevented (a protection process).

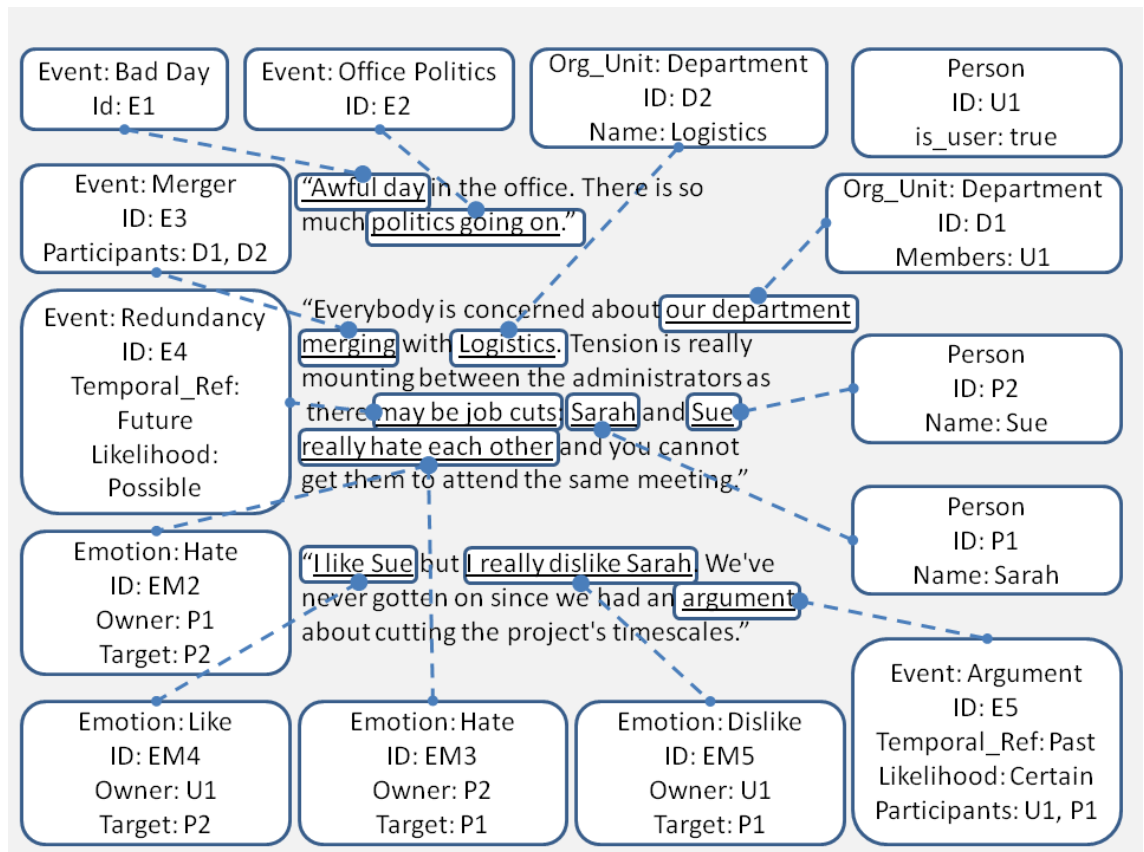


**Figure 5.2:** *An overview of the appraisal process. For the subject, or main event, under consideration the information is assessed and the following determined: how the main event impacts the user (event type), the resulting outcomes as anticipated by the Companion (event outcome) and the user (user anticipation) and the user’s emotional reaction to the event (emotional reaction). Then any additional objects are considered to determine possible event influences: threats<sup>10</sup>, antagonists, helpers and enablers.*

### 5.5.2. A categorisation of the user’s situation

From this it follows that it is possible to examine the user’s situation from their perspective, focusing on a particular event described. The nature of this event can then be categorised based on the event’s effect on the user while recognising actors and other contributing factors for the role they play within the event. The appraisal process thus consists of a series of steps to establish the effect the described situation has upon the user (Figure 5.2). These steps include the impact on the user of the event being considered, the final outcome of the event as anticipated by both the user and the Companion, a consideration of the affective response of the user and the impact of additional influences described by the user. The starting point for the appraisal process is the information received from previous modules (as a list of objects, Figure 5.3) but it also requires the selection of a single ‘main’ event from all those events discussed.

<sup>10</sup> as an event that provides a negative influence and not connected to the ‘threat to goals’ of emotional appraisal



**Figure 5.3:** Results from the Natural Language Understanding module. These are the user utterances from Example 5.1 annotated to show some of the objects returned by the NLU module. This is not a complete list of either objects or their attributes but provides a representative view of the key events described by the user. In addition to objects explicitly referenced in the user's utterances, the user is implicitly modelled as a person (top right) and can thus be referred to by other object's attributes.

### 5.5.3. Selecting the main event

The main event is selected from the list of Event objects (Figure 5.3) provided by the Natural Language Understanding module based on both the recommendation provided by the Dialogue Manager and default information within the ASM. This default information provides a ranking of importance for each possible event in order to select the most prominent event discussed by the user. The ranking is a relative judgement on the impact that a given event will have upon the user (comparative to other events) and gives preference to events with a greater impact upon the user (regardless of any wider impact). For example, general complaints of a ‘bad day’ or bad weather are deemed less significant than specific complaints about form filling or office bureaucracy. Similarly, these are deemed less significant than events with greater impact such as cutbacks or a demotion. The aim is to stop the Companion fixating on a relatively minor event when the user has mentioned a more important event. In Example 5.1, the main event is determined to be the possibility of redundancies (from “there may be job cuts”) and so the narrative response is structured around this.

### 5.5.4. The variables identified by the appraisal process

The result of the appraisal process is a series of instantiated variables representing both the impact of the situation upon the user and the user’s reaction to the situation. Table 5.2 provides an overview of these variables and the potential values they may possess.

Variable	Values
Event Type	Improvement / Deterioration
Event Outcome (Agent Anticipation)	Complete / Fail
User Anticipation	Complete / Fail
Emotional Reaction	Appropriate / Inappropriate

**Table 5.2:** *Variables from the appraisal process. These are the variables, and associated values, used by the ASM during appraisal of the main event described by the user. Each variable is assigned a value by the appraisal process based on the information provided by the user and the corresponding default knowledge of the event within the ASM’s knowledge base.*

#### **5.5.5. The event type – establishing the event’s impact upon the user**

The event type models the impact that the situation created by the event has upon the user. The ASM categorises all events as either improvements or deteriorations to the user’s situation. These are equivalent, respectively, to the amelioration and degradation modification processes of Brémont (Table 5.1). The ASM stores information on each known event covering details of their typical effects, likely outcomes and relative importance. This information is used to help assess the impact and specifies what the corresponding event type should be. In most cases the event type is a direct mapping to either improvement or deterioration. For example, redundancies are categorised as a deterioration while meeting new people can be considered, by default, as an improvement (of the social situation of the user). However, some events may take into account the sentiment shown by the user, such as determining from the user whether a meeting is an improvement or a deterioration based on the affective information provided, or in neutral situations on the Companion’s outlook (as defined as part of the Companion’s personality). (Assumptions are made as to whether a given event is an improvement or a deterioration as the nuances of a complex situation are often beyond the NLU module’s ability to recognise and incorporating specific user profiles was outside the scope of the HWYD Companion demonstrator. For example, the user may meet someone they immediately dislike or may dislike meeting new people in general but the ASM assumes that meeting new people is generally recognised as a positive.<sup>11</sup>)

#### **5.5.6. The event outcome – anticipating what will happen**

The eventual outcome of the event, in terms of whether it happened or did not happen, is also modelled. Not all events discussed will have occurred (or, having occurred, will be known to the user). For those main events where the outcome is not already known, the system stores the outcome anticipated to happen. This is modelled for both the user and the Companion independently. The anticipated outcome is formalised as having the main event either complete or fail. (Completion here being equivalent to the corresponding modification process of Brémont, based on event type, and failure being equivalent to the corresponding preservation process.) Hence the Companion stores two anticipated outcomes which may conflict. For example, the Companion may anticipate

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<sup>11</sup> However, scope permitting, it could be envisaged that the ASM would adapt the knowledge base of event types based on a user’s particular profile; hence meeting new people would become a deterioration for this user.

that a given event will complete while recognising that the user anticipates that this event will fail.

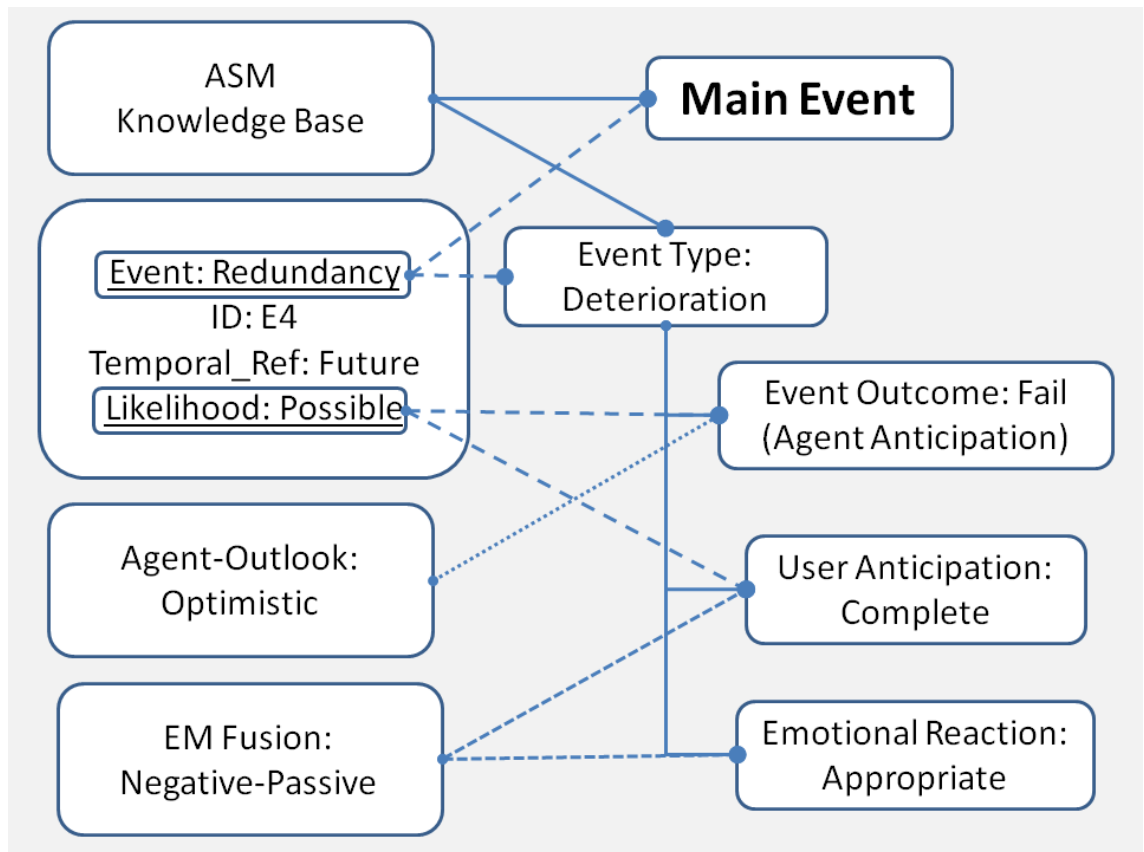
The classification of the outcome is based on both the user's language and the personality of the agent. If the outcome of an event is described as having occurred in the past then it is known to be completed. If not, as for ongoing and future events, the NLU module interprets the tense and modality of terms (such as 'may', 'might' and 'will') and attempts to assign the event a likelihood based on a five point scale: impossible, improbable, possible, probable or certain. For instance, from Example 5.1, the merger, defined in present tense, is mentioned without qualifier:

Everybody is concerned about our department merging with Logistics.

As such, the likelihood will be assigned as 'certain' (whether or not it actually is certain it should be taken seriously enough to be discussed as a real possibility) and so both the Companion (Event Outcome) and user anticipations will be assigned a status of 'complete'. However, the job cuts are defined in future tense and qualified with 'may':

Tension is really mounting between the administrators as there may be job cuts. This leads the likelihood to be assigned as 'possible'. Based on this 'possible' likelihood, the event type for job cuts being a deterioration and the user's sentiment being negative, the user anticipation is assigned a status of 'complete'. Meanwhile, the personality of the Companion, in terms of being either pessimistic or optimistic, determines the Companion's response. The lack of a definitive likelihood (definitive being either impossible or certain) and the deterioration event type leads to a status of 'complete' for pessimists and 'fail' for optimists. The contrast (or lack thereof) between the user and agent anticipations is important for determining the nature of the narrative response the Companion will provide and thus directing the generation of that response.





**Figure 5.4:** Summary of the appraisal event variables. This shows how the appraisal event variables are determined using the information from Example 5.1. The ‘Redundancy’ event is chosen as the main event based on a ranking score provided by the ASM knowledge base. Further, the knowledge base provides the information that a ‘Redundancy’ event is of type deterioration. The event type is then used in determining the anticipated outcomes and appropriateness of the user’s reaction. The Companion is optimistic, so since the deterioration event is only possible, rather than certain, the Companion anticipates that it will fail. However, the user’s anticipation is inferred from the deterioration event type and the negative affect as having the event complete. As the affective information shows a negative response to a deterioration event, the emotional reaction is deemed appropriate.

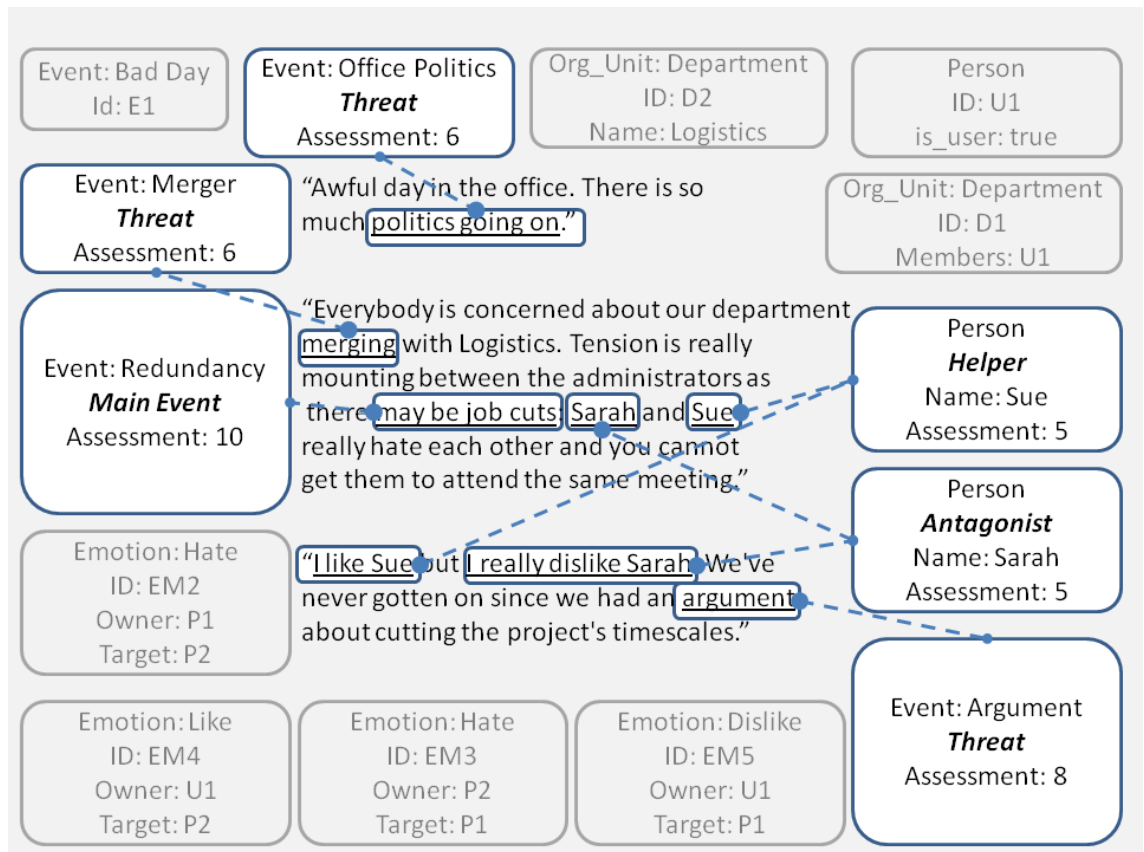
### **5.5.7. The user's emotional reaction**

The affective information is used to determine whether the user's emotional response to their situation is appropriate or inappropriate. Appropriateness is a useful metric in determining a measure of correctness in situations where there is no explicit and objective right or wrong response. Thus it is a relevant concept for conversational dialogue as it provides a means of evaluation for dialogue utterances (Webb et al, 2010). Here appropriateness is essentially measured on whether or not the user responds with negative affect to a negative situation (that is, negative valence to a deterioration) and with positive affect to a positive situation (that is, positive valence to an improvement).

### **5.5.8. Summary and additional event influences**

The combination of these four variables provides all the necessary information for determining the basic parameters of the situation described by the user. Figure 5.4 shows a summary of how the information from Example 5.1 leads to the classification of the main event.

Once the main event has been classified the appraisal process looks at any additional event influences. These event influences may be people, stated feelings or attitudes by a given person to a given subject or additional events that may impact the main event. The appraisal process assigns person objects as either antagonists or helpers based on the influence (negative or positive) they exert on the main event. Likewise, emotion and additional event objects are assigned as either threats or enablers based on their influence (negative or positive). For example, the agent instigating a deterioration main event (such as the person starting an argument with the user) would be classified as an antagonist. Likewise, a negative emotion expressed by the user (such as stating being worried about the main event) would be classified as a threat and an additional improvement event (such as a pay rise) would be an enabler. The various antagonists, helpers, threats and enablers are all assessed based on the impact they have upon the user in order to help select which should appear in the narrative response (similar to the event ranking for selecting the main event). This provides a score as a cumulative total based on independent factors that may apply in the situation. For example, if the user 'likes' (as an emotion object) a person, that person will receive a moderate (positive) score. Meanwhile if the user 'hates' a person, that person will receive a large (negative) score. Figure 5.5 depicts how the objects presented in Figure 5.3 are classified as event influences.



**Figure 5.5:** Classification of event influences. Illustrating how the objects recognised in Figure 5.1 are classified as event influences and showing their corresponding assessment of impact. The ‘Redundancy’ event is deemed as having the highest impact and assigned as the main event. Additional events, which are all deteriorations, are thus assigned as threats to the user and their ranking provides their threat assessment. The ‘Argument’ event is deemed to be most important to the user and so would be chosen over the other threats for a response. (The ‘Bad Day’ event would technically be a threat also, but as this is a low impact event deriving from the other events it is not added as a threat.) Both the helper and antagonist are derived from the like and dislike emotions (respectively) and so receive the same score. If one of these emotions was the stronger term love or hate, the assessment would be higher. The like/dislike/love/hate emotions are only valid relative to the objects they target, so do not provide threats or enablers in their own right. However, other emotions such as being worried, depressed, angry or hopeful would instantiate influences (threats in the former cases, an enabler in the latter case).

While these event influences do not directly contribute to the assessment of the main event and thus to the Companion's approach in responding to the user, they do offer additional details that may be included in the narrative response in order to provide a richer, more varied and more contextual response to the user's situation. This provides both a greater level of diversity and an enhanced realism to the response which hopefully adds to the appropriateness as perceived by the user.

## **5.6. Selecting an affective strategy**

Once the appraisal process has built this understanding of the user's situation, the understanding then informs the nature of the response provided to the user through the selection of an affective strategy. Affective strategies provide the high level direction for the composition of communication acts within the narrative response. This is not yet concerned with the selection of individual communication acts at each step of the plan. The goal of the affective strategy is rather to provide a general level of guidance which will enable the generated plan to form a cohesive whole, linking the various stages of the plan to each other and ensuring a continuous narrative without yet defining the low level details.

### **5.6.1. A breakdown of the affective strategies**

The ASM consists of six affective strategies which cover the full range of potential situations which the user may present. These are organised into pairs of oppositions (following from Brémont's arrangement of processes) which are dependent on the precise arrangement of the appraisal event variables. The basic pairing handles situations where the user and agent anticipations match and the user shows an appropriate emotional reaction: a Congratulatory strategy (for improvements) and a Sympathetic strategy (for deteriorations). The next pairing handles situations where the user and agent anticipations diverge: a Reassuring strategy (for what the agent considers improvements) and a Cautionary strategy (for deteriorations). The final pairing handles situations where the user's emotional reaction is inappropriate for the event type and is similar to the previous pairing: an Encouraging strategy (for improvements) and a Warning strategy (for deteriorations). Table 5.3 provides the breakdown of strategies for each permutation of appraisal event variables.

Affective Strategy	Event Type	Agent Anticipation	User Anticipation	Emotional Reaction
Congratulatory	Deterioration	Fail		Appropriate
	Improvement	Complete		
Sympathetic	Deterioration	Complete		Appropriate
	Improvement	Fail		
Reassuring	Deterioration	Fail	Complete	Appropriate
	Improvement	Complete	Fail	
Cautionary	Deterioration	Complete	Fail	Appropriate
	Improvement	Fail	Complete	
Encouraging	Deterioration	Fail	Complete	Inappropriate
			Fail	
	Improvement	Complete	Complete	
			Fail	
Warning	Deterioration	Complete	Complete	Inappropriate
			Fail	
	Improvement	Fail	Complete	
			Fail	

**Table 5.3:** *Selecting an Affective Strategy. This table shows details of how the various combinations of appraisal event variables lead to a particular affective strategy being selected. There are six different affective strategies covering all permutations of the appraisal event variables with each strategy having a particular focus. The Congratulatory and Sympathetic strategies centre on those situations where the agent and user anticipation match. The Reassuring and Cautionary strategies centre on those situations where there is a difference between the agent and user anticipation. The Encouraging and Warning strategies centre on an inappropriate emotional reaction (thus the agent and user anticipation are not relevant).*

### **5.6.2. The character of the individual affective strategies**

Each strategy has its own particular character which acknowledges the situation described by the user and seeks to provide an appropriate form of influence that can be enacted on the user.

- A Congratulatory strategy acknowledges a situation which both user and Companion view as being beneficial to the user and so the Companion attempts to reinforce the positive nature of the situation and express a positive affect.
- Conversely, the Sympathetic strategy acknowledges a situation which both user and Companion view as being detrimental to the user and from which the user has no recourse. As such the Companion seeks to express a negative affect and assuage the user of responsibility for the situation.
- A Reassuring strategy acknowledges what appears to be a negative situation from the user perspective but which the Companion regards as redeemable. The Companion will thus acknowledge the negative aspects but attempt to downplay them and highlight the positive aspects instead.
- Meanwhile, a Cautionary strategy targets a situation the Companion regards as potentially negative but the user does not. Here the Companion attempts to highlight the negative aspects for the user while, as with the Sympathetic strategy, relieving the user of responsibility.
- The Encouraging and Warning strategies are similar to the Reassuring and Cautionary strategies (respectively) but rather than focusing on a mismatch between anticipations they feature a mismatch in emotional response (with the anticipations potentially matching). As such the Encouraging strategy seeks to highlight the positive aspects and to push the positive affect of the situation while the Warning strategy highlights the negative aspects and attempts to push the negative affect.

### **5.6.3. Examining the strategy of Example 5.1**

Taking the situation described in Example 5.1 (and the corresponding appraisal event variables shown in Figure 5.4) the corresponding affective strategy chosen by the system is a Reassuring strategy. As such, the Companion will seek to acknowledge that the situation (potential job cuts) appears negative and that a negative emotional reaction is appropriate for the situation. Further, the Companion will then respond to this by challenging the user's anticipation, downplaying the negative aspects and highlighting the positive aspects. The Reassuring strategy thus sets the tone of the response provided to the user but the exact composition of the response, including which communicative acts are employed and what event influences are selected, depends on the final step in which a plan for the narrative response is generated.

## **5.7. Conclusion**

This chapter has discussed the approach to persuasion, inspired by Brémond (1973), taken by the Affective Strategy Module. This approach is reliant on assessing the impact upon the user of the events discussed, as well as the user's response to these events, and using this to select a means of influence which can be embedded within the narrative response. This chapter has further specified the three stages of the generation of a narrative response by the ASM: appraisal of the user's situation, selection of an affective strategy and generation of a plan for the narrative response. The process of appraisal has then been discussed in detail along with the various affective strategies employed by the ASM. The following chapter goes on to discuss the process of generating a plan of communication acts using the affective strategy selected.

## **6. Planning Narrative Responses**

### **6.1. Introduction**

With the appraisal of the user's situation allowing the selection of an affective strategy, this affective strategy can now be employed by the Affective Strategy Module in order to guide the generation of a plan for the narrative response. This chapter will discuss the planning technology used and detail the process followed by the ASM. This will be illustrated by examples for each of the affective strategies available to the ASM.

### **6.2. HTN Planning**

The ASM employs a modified version of the Hierarchical Task Network (HTN) planner used in the Cognitive Model which showed both power and flexibility in the composition of dialogue plans for the Health and Fitness Companion. HTN planning is one of the most widely used planning techniques (Ghallab et al, 2004). Compared to classical planning techniques, HTN planners can employ both a more sophisticated knowledge representation and increased reasoning abilities. They can also solve classical planning problems faster than classical planners. The counter-balance is that to accomplish the planning process HTNs require the definition of domain information to a level beyond that required by classical planning.

HTN planning is a decompositional planning approach. Starting with a high level task, the planner breaks down this task into sub-tasks which are then recursively decomposed until a series of primitive tasks result. A primitive task is a task that does not require (that is, warrant) further decomposition but can be applied directly to the world state using an operator. Therefore the given high level task can be accomplished by following the set of operators produced by the planner. (An operator is thus equivalent to an action in classical planning terminology.) The instructions for defining how higher level tasks are broken down into sub-tasks are called methods.

A further benefit of HTN planning is the degree of abstraction that can be achieved through the decomposition process. A great deal of flexibility and variability can be realised that results in the ability to produce a much more complex and nuanced ordering of items than is readily achievable without the use of planning. HTN planning thus compliments the process of assembling a plan of communication acts and the



requirement of domain information is not problematic as the ASM does not require domain-independent reasoning. Further, HTNs have previously been used in Interactive Storytelling (Cavazza et al, 2002) for planning character actions within a narrative. As such, this approach seems suited to producing a plan for a narrative response capable of incorporating influence.

### **6.3. Implementation details**

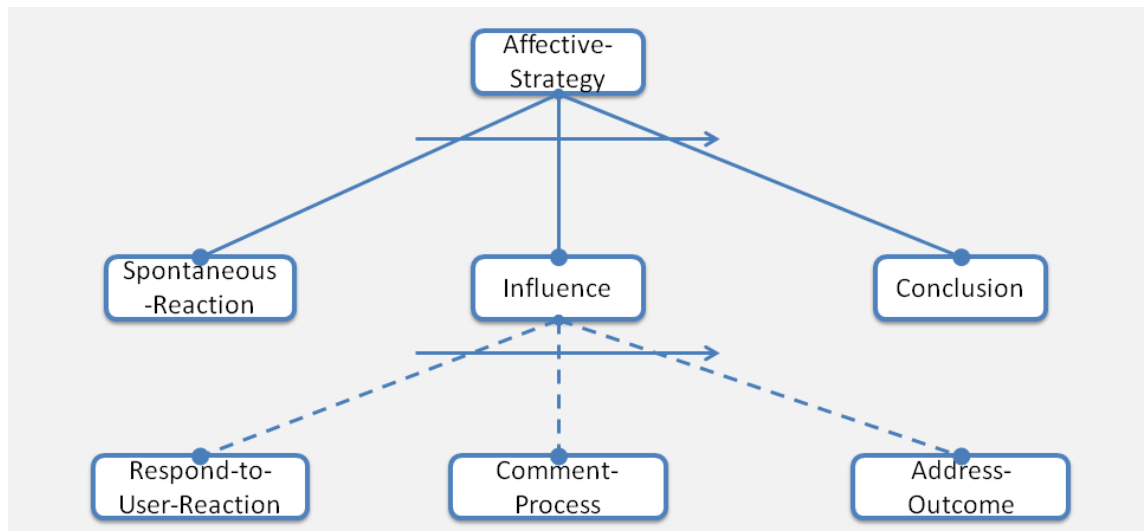
Within the HWYD Companion, my bespoke HTN planner is utilised to provide a decomposition of the task of generating a narrative response. This decomposition is accomplished using a heuristic selection process and results in a plan of operators that define the overall narrative response to be provided by the Companion.

#### **6.3.1. HTN Planner implementation**

My approach to HTN planning is inspired by the SHOP planner (Nau et al, 1999) and based on the standard Total-Order Forward Decomposition algorithm for HTN in (Ghallab et al, 2004). My implementation is written in Common Lisp and includes several standard extensions such as axiomatic inference and attached procedures (using Lisp). Further, my HTN planner includes a heuristic selection process with the ability to attach semantic tags to methods. Semantic evaluation rules are then used to compute a metric which allows the planner to choose between multiple applicable methods. As with the Cognitive Model, the ASM makes use of these semantic tags to direct the decomposition. This allows for the response to be adapted to the information provided by the user while remaining consistent with the selected affective strategy. Further details of the implementation of my HTN planner are provided in Appendix C.

#### **6.3.2. A decompositional approach to narrative generation**

The HTN planner is used to construct a plan of communication acts which will be realised into the individual utterances of the Companion's narrative response by the NLG module. The task of creating the narrative response is thus recursively decomposed into sub-tasks until only a series of primitive tasks are left (with the primitive tasks being accomplished by the plan operators).



**Figure 6.1:** *Decomposition of the Affective-Strategy task. Illustrating the decomposition of the top levels of the Affective Strategy HTN when generating a plan for the narrative utterance. Each plan consists of a Spontaneous-Reaction task, the Influence task and a Conclusion task. The Influence task further breaks down into Respond-to-User-Reaction, Comment-Process and Address-Outcome tasks which each focus on a different area of influence. The top level of the decomposition is fixed, so plans will always consist of a Spontaneous-Reaction, Influence and Conclusion in that order. However, the further decomposition of the Influence method is not fixed and so plans may feature the Respond-to-User-Reaction, Comment-Process and Address-Outcome methods in differing orders (hence six possible decompositions from this level alone). The order selected for a given plan is determined by semantic evaluation rules.*

Figure 6.1 shows the upper levels of this task decomposition. At the highest level, the ASM starts with an **Affective-Strategy** task which encapsulates the narrative response to be provided. The first level of decomposition separates this into tasks dealing with the initial affective response to the user, the **Spontaneous-Reaction** task, the main body of the narrative response which attempts to positively influence the user, the **Influence** task, and finally a summary of the Companion's response, the **Conclusion** task. The **Influence** task is further sub-divided based on the area of influence: the **Respond-to-User-Reaction** task deals with the user's reaction and their anticipated outcome, the **Comment-Process** task dealing with additional influences and the **Address-Outcome** task relating the Companion's anticipated outcome.

Each of these sub-tasks are then further decomposed, often with multiple options for how this decomposition may be accomplished. For example, the **Respond-to-User-Reaction** task can be decomposed following one of four different approaches (see Figure 6.2): a comparison can be drawn between the user's reaction to their situation and their anticipation for that situation's resolution with either the **Compare-Anticipation-to-Situation** or **Compare-Situation-to-Anticipation** tasks or the Companion can choose to focus on only one of these areas with either the **Focus-on-Anticipation** or **Focus-on-Situation** tasks. Similarly the **Compare-Process** task can be decomposed using one of four approaches (see Figure 6.4): by considering only the positive aspects with the **Focus-on-Positive-Influences** task, by considering only the negative aspects with **Focus-on-Negative-Influences** task, by focusing on the different events that affect the user with the **Contrast-Event-Influences** task or finally by comparing the different actors involved in the user's situation with the **Contrast-Actor-Influences** task.

The decomposition can thus be seen to be made up of a combination of AND and OR branches which control the form of the HTN; the AND branches sub-divide a task into multiple branches and therefore refine the granularity of the task while the OR branches provide a choice of decomposition and therefore specialise the task. This decomposition process continues until each individual branch results in a primitive task. Each primitive task is accomplished by an individual operator with the series of these operators in sequence composing the final plan.

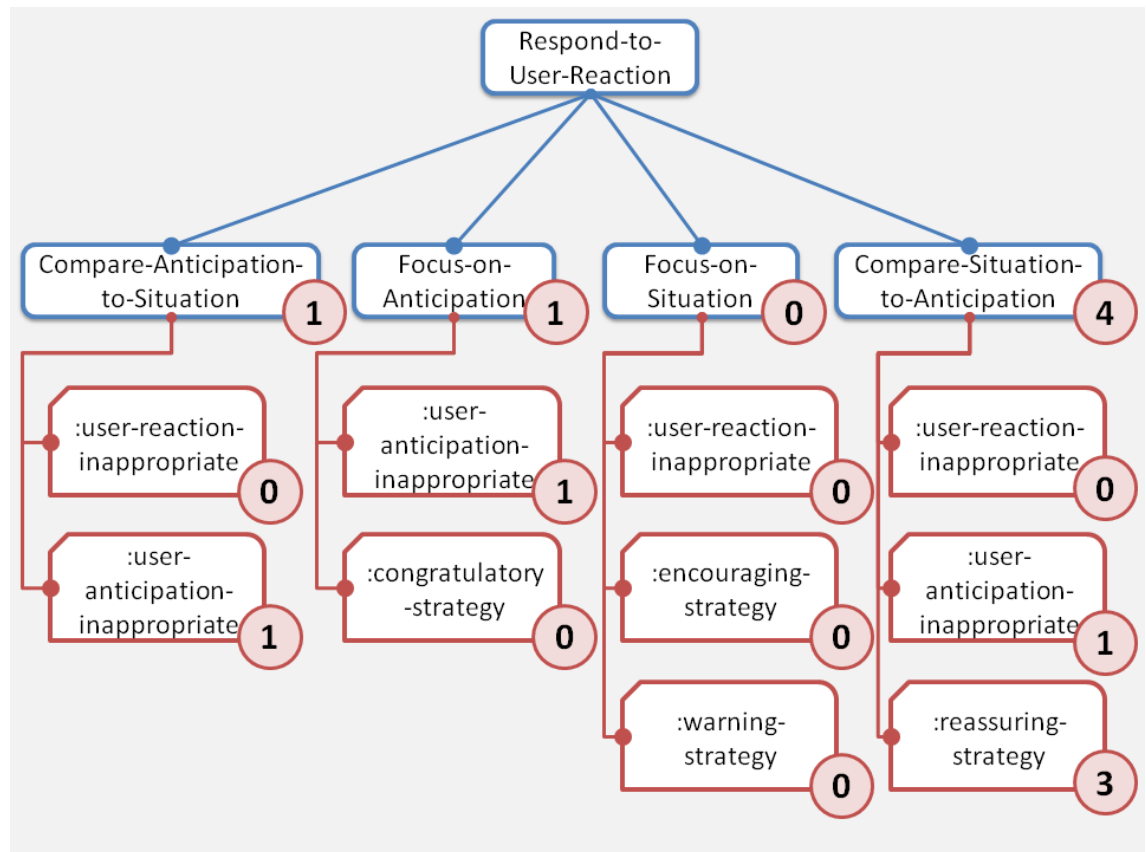
It should be noted that the decomposition process is not hard-coded to particular situations or particular strategies. While certain decompositions will be better suited to certain situations, there are always a range of decomposition options available for each strategy and each situation. The role of the HTN planner is to select the most appropriate decomposition from these options. The high-level task of creating the narrative response is thus gradually refined and specialised throughout the decomposition process to provide a solution tailored to the specific situation outlined by the user.

The selection of a particular decomposition is determined by the results of the appraisal variables and the selected affective strategy. The HTN planner uses semantic tags along with the heuristic selection process in order to select between the applicable OR branches and to complete the decomposition.

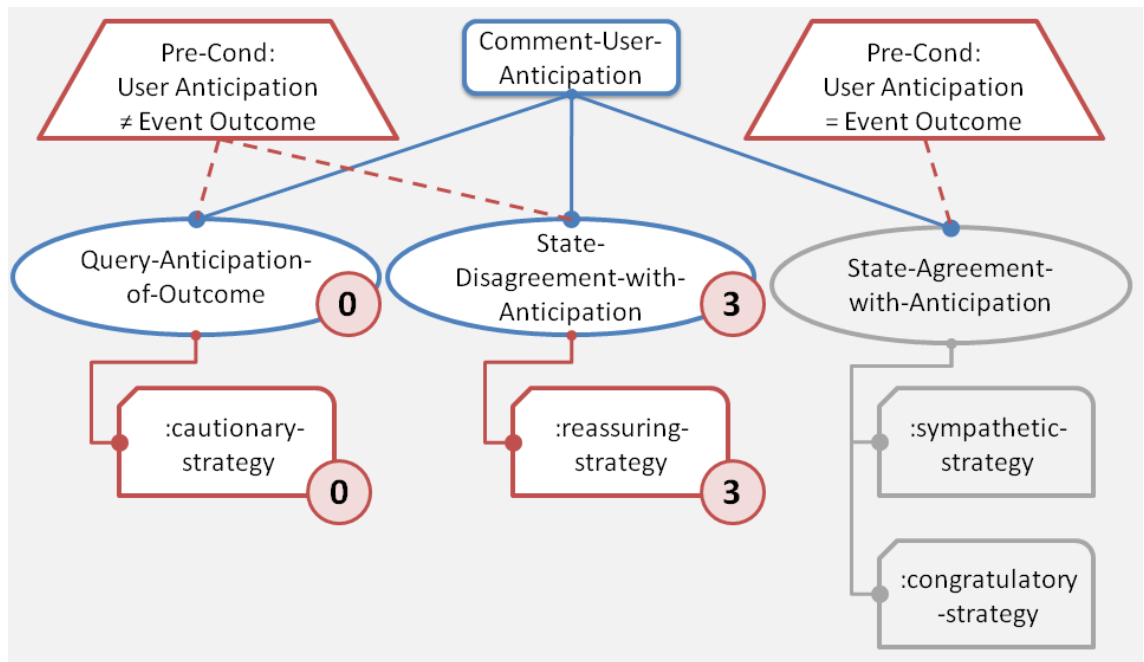
### **6.3.3. The use of semantic tags**

Semantic tags are used at multiple levels throughout the decomposition of the **Affective-Strategy** task (Figure 6.1) which serves to exert increasing control by the chosen affective strategy and gradually specialises the resulting plan. Thus the upper levels remain general across plans: the first level of decomposition is fixed for every plan, the second level (decomposition of the **Influence** method) employs the same three methods across every plan generated but their ordering is tailored for each plan using semantic tags. For example, tags such as **:focused-on-main-event** will give a high score when the user does not provide much additional information while **:multiple-influences** will score higher for situations when the user provides a lot of additional information. These tags then contribute to whether **Address-Outcome** or **Comment-Process** methods are given a more prominent position in the plan.

At further levels of decomposition the semantic tags control the selection between alternate branches of applicable methods which further shapes the form of the resulting plan. Figure 6.2 shows how semantic tags advise in the decomposition of the **Respond-to-User-Reaction** method for Example 5.1/6.2. A distinction should be drawn here between the use of pre-conditions and semantic tags as both are used to control the decomposition process. Pre-conditions define whether a given method is applicable in the given situation, pruning branches that do not apply. Meanwhile, semantic tags are used as a heuristic to choose between the remaining applicable branches and to guide toward more suitable choices. Figure 6.3 distinguishes between these approaches in the decomposition of the **Comment-User-Anticipation** method used in Example 5.1/6.2.



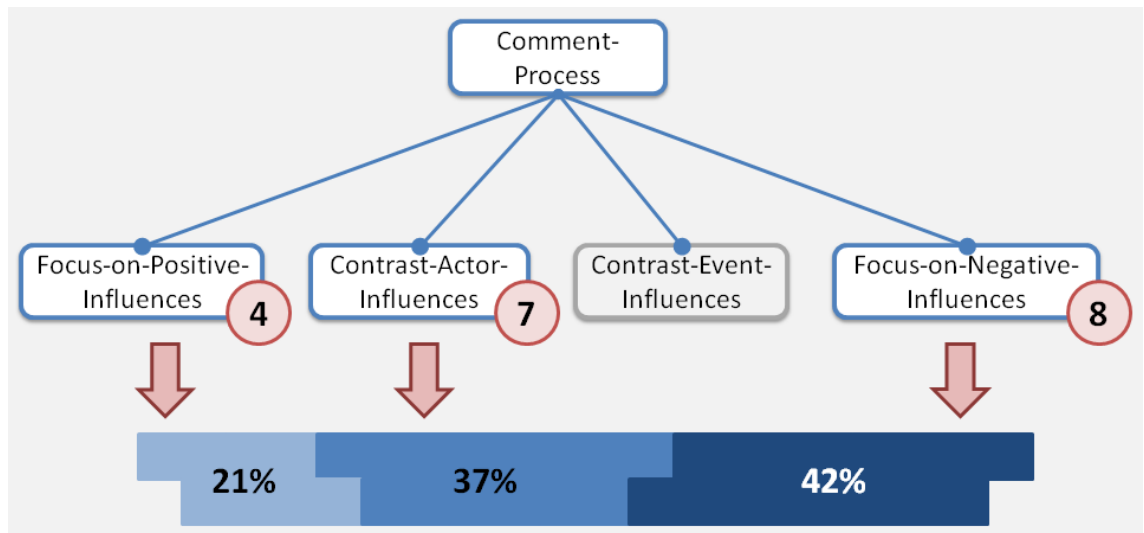
**Figure 6.2:** *Decomposition of the Respond-to-User-Reaction task. Showing the four possible decompositions of the task and the semantic tags attached to each which then directs the selection of a given sub-task. Each decomposition comments on the user's situation and their anticipation but does so using a different approach (and the assigned semantic tags reflect this). Semantic evaluation rules provide a score for each semantic tag based on the information provided by the user and scores are then totalled for each method. The scores shown here represent a Reassuring strategy as selected in Example 5.1/6.2. As the user's anticipation is inappropriate here the best course of action is to provide a comment upon this. Thus all of the methods except **Focus-on-Situation** score a point. Further, **Compare-Situation-to-Anticipation** is deemed particularly appropriate for a Reassuring strategy and so scores additional points. In a different situation, such as with a Warning strategy, the scoring would be different (and for a Warning strategy essentially the opposite) and the planner would be more likely to select **Focus-on-Situation**.*



**Figure 6.3:** *Contrasting pre-conditions and semantic tags. Illustrating the use of semantic tags and pre-conditions for determining a decomposition for the **Comment-User-Anticipation** task. Of the operators shown, **Query-Anticipation-of-Outcome** and **State-Disagreement-with-Anticipation** both require that the user’s anticipation does not match that of the system. Meanwhile **State-Agreement-with-Anticipation** requires that the user’s anticipation does match that of the system. For a situation such as that in Example 5.1/6.2, it would not make sense for the Companion to state that it agrees with the user’s anticipation as it does not. Thus the pre-condition prevents **State-Agreement-with-Anticipation** from being selectable. While it does make sense for the system to question the user’s anticipation with **Query-Anticipation-of-Outcome**, such an approach is too confrontational and would not be appropriate for a Reassuring strategy. Hence, this operator is scored as less appropriate than **State-Disagreement-with-Anticipation** based on the semantic tags. However, it is not removed entirely as it is still applicable to the situation. (Note that not all operators for decomposing **Comment-User-Anticipation** are shown in this example, whether applicable or not for this situation.)*

Throughout the decomposition then, semantic tags guide towards a final selection of operators for the plan. This approach provides several benefits, such as ease and flexibility in defining the domain: the hard constraints are defined in pre-conditions while subtler factors can be incorporated into semantic evaluation rules without worrying about ensuring logical tautologies across methods and operators. The principal benefit, however, lies in allowing variability in the plan composition, even amongst plans for one particular situation presented by the user, while preserving the overall coherence of a given strategy. The terminology used above when referring to the semantic tags, such as ‘guide’ or ‘advise’, is important as the semantic tags merely provide a metric for selecting appropriate options rather than dictating hard-coded solutions. Indeed, there is no guarantee that the semantic scoring will always provide an absolute ranking or prominent choice when alternatives are equally valid.

The semantic scoring procedure (as explained in Figure 6.2) provides a metric for determining the suitability of each applicable method by assigning a score to each. In order for a given method to be selected, it must be ‘significantly’ ahead of the next nearest option (with significant here being defined by a variable within the HTN planner indicating a required score difference). If this is not the case then all options within a defined score threshold of the leading option (or options, if there are several) are taken and weighted based on their score. The HTN planner then selects randomly between the weighted items but with the more heavily weighted items receiving a correspondingly higher chance of selection. Figure 6.4 shows the selection process for the decomposition of **Comment-Process** used in Example 5.1/6.2. Combined with the variability of form provided by the Natural Language Generation module for each operator, this approach ensures narrative responses (even amongst very similar situations) do not appear repetitive or overly formulaic and hence are more natural for the user.



**Figure 6.4:** *The selection process for a decomposition of Comment-Process. The scores shown are from Example 5.1/6.2 which features an antagonist, a helper and three threats. Note that the Contrast-Event-Influences method is not applicable in this situation as there are no enablers to contrast with the threats. Of the applicable methods, Focus-on-Negative-Influences scores highly due to the three threats and one antagonist mentioned, with Contrast-Actor-Influences a close second due to the antagonist and helper. As the Focus-on-Negative-Influences method is not ‘significantly’ ahead (which requires being 2 points clear) then all methods within the defined threshold are included in the weighting process. (Note that the threshold is 8 points, so if Contrast-Event-Influences had been applicable but had scored 0 points it would still not be featured in the weighting.) The weighting means that the Focus-on-Negative-Influences method has a 42% chance of selection, the Contrast-Actor-Influences method has a 37% chance and the Focus-on-Positive-Influences method a 21% chance. In Example 5.1/6.2, the Focus-on-Negative-Influences method was selected but if the example was re-run, any of the three methods could be selected instead (with the given probabilities of selection).*



#### 6.3.4. The form of the generated plan

The final plan presented by the ASM consists of a set of operators, with each operator specifying a communication act that will be utilised by the NLG module to form a system utterance. Each operator provides a base function, or action, which specifies the communicative act to be performed with optional additional parameters that specify further details and attached performative information to support multimodal output:

((**Action** Param Param Param)  
(*Performative information*))

In addition, the plan is sent with the complete ASM state information. This is a list of key-value pairs which provides all the object information previously provided by the Natural Language Understanding module along with further ASM-generated variables. These extra ASM variables provide the results of the appraisal (such as affective strategy, event type, etc). This ASM state information is provided to allow the NLG module to further adapt the resulting utterance (for example, to offer alignment with user phrasing such as using ‘concerned’ rather than the system’s default ‘worried’) and thus build rapport with the user. Example 6.1 presents the ASM plan that corresponds to the output generated in Example 5.1 of the previous chapter and is presented again in Example 6.2 later in this chapter.

As discussed previously, performatives allow an ECA to provide communication that goes beyond the speech modality. The format used within the HWYD Companion follows an FML-like language (Heylen et al, 2008) developed by COMPANIONS project partners Telefónica (Hernández et al, 2008). This provides the ECA with the ability to convey information across a range of modalities such as with gestures and facial expressions. The four values consist of a ‘performative’, a ‘gesture’, the ‘affect’ and the ‘emphasis’. The ‘performative’ references a set of performative categories encapsulating the intent behind the utterance, the ‘gesture’ (diverging from the BML/FML modular scheme) provides for further specific gesture information (although this is not used in the current HWYD Companion version), the ‘affect’ references a set of emotions used by the agent and the ‘emphasis’ allows the agent to emphasise the importance of a given utterance. The ASM determines the appropriate performative and associated information for each operator: the ‘performative’ is set based on the action employed, the ‘affect’ based on the user’s emotional valence and the ‘emphasis’ based on the user’s emotional arousal.

- 1: ((**Empathise** Negative Low Negative Low)
- 2:       (Recognise Main Sadness Weak))
- 3: ((**State-Agreement-Regarding-Situation**)
- 4:       (Agree Main Sorry-For Weak))
- 5: ((**State-Disagreement-With-Anticipation**)
- 6:       (Disagree Main Relief Weak))
- 7: ((**Express-Agent-Opinion** E4 Negative)
- 8:       (Inform Main Sadness Weak))
- 9: ((**Express-Likelihood-Of-Result** Event-Actualised
- 10:   Only-Voluntary-Redundancies Positive-Aftermath Nil)
- 11:       (Inform Main Relief Weak))
- 12: ((**Play-Down-Antagonist** P1)
- 13:       (Inform Main Relief Weak))
- 14: ((**Promote-User-Ability**)
- 15:       (Praise Main Hope Weak))
- 16: ((**Play-Down-Threat** E5)
- 17:       (Inform Main Relief Weak))
- 18: ((**Play-Down-Threat** E2)
- 19:       (Inform Main Relief Weak))
- 20: ((**Provide-Moral**)
- 21:       (Inform Main Relief Weak))

**Example 6.1:** *Example of a final ASM plan. This is an ASM plan corresponding to the output generated in lines 7-16 of Example 5.1/6.2. The plan consists of a list of tuples, with each tuple containing two predicates. Each tuple corresponds to a single system utterance with the first predicate providing the actual operator (line 1, 3, etc) and the second predicate providing the performative and associated information (line 2, 4, etc). For each operator, the main communicative function (or action) is provided in bold with parameters in normal type. Some operators (line 3, 5, 14, 20) provide no additional parameters and rely on the ASM state information (not shown here) to specify the details (such as the anticipations for line 5 and the strategy for line 20). Some operators fully specify the resulting communicative function with their parameters (line 1, 9) and others reference objects stored in the ASM state (line 7, 12, 16, 18). (The full ASM state provides the information from Example 5.1/6.2 including that discussed in Figures 5.3, 5.4 and 5.5. It can be viewed in Appendix D.)*

### 6.3.5. The design of the operators

The operators are designed to carry sufficient information so as to be able to convey the communicative function without dictating the final form realised by the NLG module. Thus, while naming of actions may appear prescriptive, this naming serves to differentiate between communicative functions rather than to describe the form of the resulting utterance. For each operator the NLG module provides some variation in how the resulting utterance may be realised. For example, **State-Disagreement-With-Anticipation** serves as a counter to **State-Agreement-With-Anticipation**, yet the former may be realised in multiple ways such as:

I'm not sure you fully understand the effect the redundancies might have on you.

Or such as:

You are perhaps wrong about how the redundancies might affect you.

Similarly, operators can use parameters to further specialise the nature of the response without specialising the form of the response. For example, the **Sympathise** action uses parameters which specify the affective information to be used when communicating an affective stance to the user:

(Sympathise ?valence ?arousal ?ev-valence ?ev-arousal)

This can be instantiated, in a positive situation, as:

(Sympathise Positive Low Positive Low)

Resulting in an utterance such as:

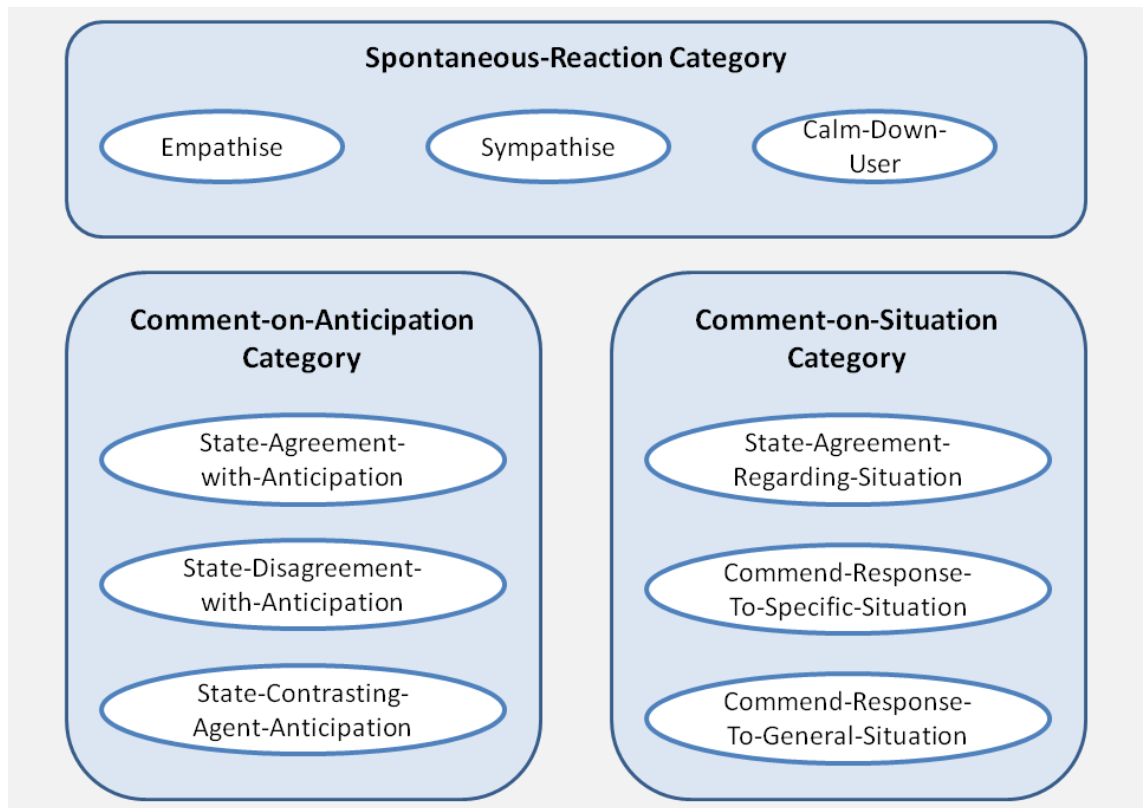
I'm glad to see you're happy about the situation.

While an instantiation of a negative situation would look like:

(Sympathise Negative Low Negative Low)

Which would result in an utterance such as:

What you are going through must be difficult?



**Figure 6.5:** HWYD domain operators and operator categories. Illustrating some of the different operator categories and some of the corresponding operators within each category. Categories group operators based on the particular function within the narrative response that they provide. Inside each category, there are operators providing both opposing (such as *State-Agreement-With-Anticipation/State-Disagreement-With-Anticipation*) and similar functions (such as *State-Disagreement-With-Anticipation/State-Contrasting-Agent-Anticipation*).

I have created over 50 individual operators with each one representing a particular communication act. The operators were designed around a number of categories with each operator in a given category providing a different communicative function to the others (Figure 6.5). This includes both those operators providing opposing functions and those operators with similar functions but a differing focus. Each category focuses on a particular aspect of the overall narrative response including: categories centring on the affective aspect of the response, categories commenting on the user's situation and their anticipated outcome, categories discussing event influences, categories discussing the eventual outcome or result envisaged by the Companion and a conclusion category for summarising the Companion's affective strategy. The generation of a plan for the narrative response thus consists of compiling a sequence of operators where each

selected operator provides a function complementing the overall affective strategy (and is thus able to exert the influence required when the operators are realised).

#### **6.4. Presenting examples of affective narrative responses**

The rest of this chapter (and the next chapter) will refer to examples, similar to Example 6.2 below, consisting of user utterances and corresponding output from the completed HWYD Companion. Due to the range of modules involved and the corresponding amount of information processed the examples will present multiple lines of annotated information for each dialogue turn. A line number is provided for each utterance (both user and system) to allow easier identification of specific sections of the dialogue.

User turns include:

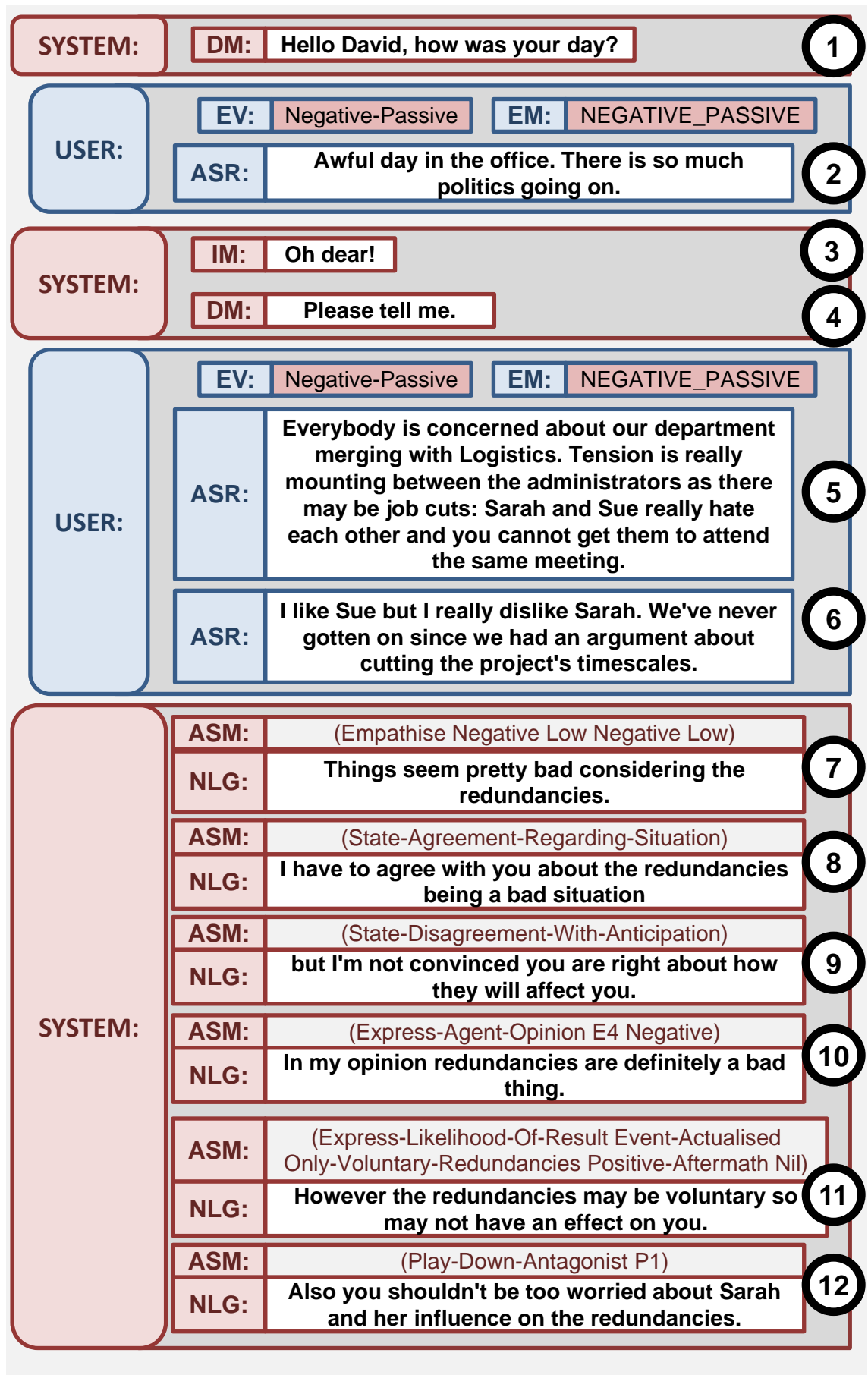
- “EV” indicating the value returned by EmoVoice,
- “EM” indicating the value of the fusion of emotional data (integrating both the EmoVoice and Sentiment Analysis results over time) and
- “ASR” indicating the text returned by the ASR (with “Actual” results where this differs notably from what was said).

A user turn may consist of multiple utterances with both EmoVoice and the ASR chunking user input independently which may lead to an imbalanced number of EmoVoice and ASR utterances. EmoVoice tends to be more conservative so normally one or more ASR utterances will be encapsulated by single EV and EM annotations.

System turns specify the output as:

- “IM” indicating the ‘Short Loop’ response,
- “DM” indicating a comment or question directly from the DM,
- “ASM” indicating the operator produced by the ASM (performative information is not shown) and
- “NLG” indicating the final generated utterance based on the ASM operator.

These also may include multiple utterances per system turn, particularly with a narrative response.



SYSTEM:	ASM:	(Promote-User-Ability)	13
	NLG:	With your skills you shouldn't have a problem handling the redundancies.	
	ASM:	(Play-Down-Threat E5)	14
	NLG:	You shouldn't get too preoccupied about the argument.	
	ASM:	(Play-Down-Threat E2)	15
	NLG:	Also you shouldn't think too much about the office politics.	
	ASM:	(Provide-Moral)	16
	NLG:	Remember that sometimes things work out okay in the end.	

**Example 6.2:** *Conversation with a Reassuring narrative response. This is the dialogue of Example 5.1, with auxiliary information, and demonstrates the Companion employing a Reassuring affective strategy.*

## 6.5. An example of a Reassuring narrative response

In Example 6.2 (and the corresponding plan in Example 6.1) we see how the operators are employed to provide a Reassuring strategy for the user. The goal of the Reassuring strategy is to acknowledge the negative situation faced by the user but to then challenge, in a supportive manner, the user's negative outlook on this.

### 6.5.1. Engaging with the user's emotions – Spontaneous-Reaction

The first step here, as in every strategy, is to engage with the affective state of the user. This Spontaneous-Reaction (Figure 6.1) does not attempt to tackle the subject of the conversation – identified by the main event – but rather to focus solely on grounding with the user's affective state as provided by the Emotional Model (via the Dialogue Manager).

An Empathise operator is employed for this effect (line 7, Example 6.2):

(Empathise Negative Low Negative Low)

It attempts to convey that the Companion understands and shares (hence, empathise with) the user's emotional state. Parameters define the emotional state as having a negative affect and low arousal<sup>12</sup>, to wit, that the user is sad or depressed. The

<sup>12</sup> In fact, the operator appears to provide these parameters twice as it passes both the initial result from EmoVoice, as used in the 'Short Loop' (Figure 3.1), and the final result produced by

communicative function thus attempts to anchor that the Companion has understood the user to have a negative emotional state, that this is appropriate for the situation and that the Companion endorses the user's attitude.

### **6.5.2. Challenging expectations – Respond-to-User-Reaction**

Following this Spontaneous-Reaction, the Companion then begins the Influence process (Figure 6.1) which starts to engage with the main event as determined by the appraisal process. In this example, this consists of employing the Respond-to-User-Reaction branch of Influence which further consists of a State-Agreement-Regarding-Situation operator (line 8, Example 6.2) followed by a State-Disagreement-with-Anticipation operator (line 9, Example 6.2):

(State-Agreement-Regarding-Situation)  
(State-Disagreement-With-Anticipation)

These two operators work together to present the main thrust of the Companion's response to the user, with the former operator continuing the process of acknowledging the negative situation started with the Empathise operator and the latter challenging the natural progression of this thought. The close relationship between these two operators can be seen in the way the NLG module realises both of these operators as a single utterance with a disjunctive (lines 8 and 9, Example 6.2):

I have to agree with you about the redundancies being a bad situation  
but I'm not convinced you are right about how they will affect you.

No further parameters are required here as the situation and anticipation recognised by the Companion are both detailed in the corresponding appraisal variables within the ASM state (which is also passed to the NLG module along with the plan of operators).

The State-Agreement-Regarding-Situation operator belongs to the Comment-on-Situation category of operators (Figure 6.5). These operators focus on the user's emotional reaction but rather than just acknowledging the reaction itself, as with the Spontaneous-Reaction category, this acknowledgement is explicitly tied to the situation described by the user and focused upon by the main event.

Similarly, the Comment-on-Anticipation category (Figure 6.5), of which State-Disagreement-with-Anticipation is a member, focuses on the difference in the eventual outcome anticipated by Companion and user. The difference or similarity in

---

the Emotional Model as used in the ASM. This allows the NLG to address any difference between the two values and prevent a mismatch between the 'Short Loop' and ASM output.



anticipation is of key importance in several strategies as it either provides a means of acknowledging and reinforcing a correct opinion, as with a Congratulatory strategy, or provides the core point around which a means of influence is based, as with a Reassuring strategy.

### **6.5.3. The Companion's affective response – Express-Agent-Attitude**

The next operator is Express-Agent-Opinion (line 10, Example 6.2):

(Express-Agent-Opinion E4 Negative)

This returns to dealing with the user's affective state and attempts to reinforce the appropriateness of the emotional reaction by stating a negative opinion of the redundancies (event object E4 referenced in the parameter). This operator is of the Express-Agent-Attitude category which, along with the Spontaneous-Reaction category, focuses solely on communicating affective aspects rather than providing a direct means of influence. However, within the context of the overall plan, these categories can still contribute to the influence of the Affective Strategy through their sequencing with other operators. Affective operators such as Express-Agent-Opinion are normally employed in situations where the user's emotional reaction is deemed inappropriate, namely with Encouraging or Warning strategies, in order to reinforce what the Companion considers to be an appropriate response to the situation.

In the current example, the use of this operator highlights the flexibility provided by semantic tags and the ability for the ASM to incorporate subtle influences provided these are captured within the semantic evaluation rules. The inclusion of Express-Agent-Attitude category operators depends on the selection between two alternative branches with opposing semantic tags, namely :emotional-response for inclusion of the category and :non-emotional-response for exclusion of the operators. Semantic evaluation rules add points to :emotional-response when the user's emotional reaction is inappropriate while :non-emotional-response receives points when the emotional reaction is appropriate resulting in the standard behaviour, referred to above, of including such operators in Encouraging or Warning strategies. However, an additional semantic evaluation rule provides points for emotion objects on the reasoning that discussion of emotions by the user warrants a similar response from the Companion. Thus the inclusion of several emotion objects in Example 6.2 provides a counter-balance to the appropriate emotional reaction and leads to the inclusion of the Express-Agent-Opinion operator. As such, the operator serves to reinforce the appropriate

emotional reaction, as well as the correctness of the user's response, amongst the various emotional reactions discussed and to potentially lessen the impact of disagreeing with the user over their anticipation.

#### **6.5.4. Offering a better future – Address-Outcome**

Following this is the Express-Likelihood-of-Result operator (line 11, Example 6.2):

(Express-Likelihood-Of-Result  
Event-Actualised Only-Voluntary-Redundancies Positive-Aftermath Nil)

Here the Companion switches back to attempting to influence the user's recognition of their situation, this time by addressing the Companion's anticipated outcome. As part of a Reassuring strategy, this involves reassuring the user that the eventual outcome may not be as bad as feared by the user. Express-Likelihood-of-Result belongs to the Comment-on-Result category which, along with the more general Comment-on-Outcome category, is used in the decomposition of the Address-Outcome method (Figure 6.1). To understand the Comment-on-Result category, it is easier to first present the Comment-on-Outcome category from which it is derived.

Comment-on-Outcome category operators consist of two principal parts: an action and a parameter. The ?action dictates the means of influence while the parameter dictates the ?subject and ?process enacted by the influence:

(?action ?process-?subject)

Within the Comment-on-Outcome category, the ?subject describes a property and the ?process describes how the property will change. For example, the ?subject of the redundancies in Example 6.2 is the user's motivation. The ?process then, depending on the corresponding ?action employed, is either to conserve the user's motivation or to decrease the user's motivation. This corresponds to an ?action referring to either a protection process or a degradation process respectively (Table 5.1). The ?action qualifies the form of influence so, for a Reassuring strategy, the actions would either promote the protection process or demote the degradation process such that both would result in a positive outcome. For example, for promoting a protection process:

(Express-Likelihood-Of-Outcome Conserve-Motivation)

would attempt to emphasise the likelihood that the user's motivation would remain unchanged and not decrease. Alternatively, the Companion could demote the degradation process:

(Play-Down-Likelihood-Of-Outcome Decrease-Motivation)

which would attempt to diminish the likelihood that the user's motivation would be decreased and therefore that it would be unchanged.

There are a range of subjects which are suitably generic in nature to be applied across different events: stress, workload, colleague relations, quality of life, mood, reputation, motivation and the impact on a user's time. The ?process then indicates whether the ?subject will be increased, decreased or conserved based on the anticipated outcome. While the subjects cover a wide range of events, not all subjects are suitable for all events and the particular processes employed depend on the specific event. Thus the ASM's knowledge base holds information on which subjects and processes should be applied to which events. For example, in Example 6.2 the threat of department-wide redundancies may decrease motivation, while an argument may decrease colleague relations and missing a work meeting may decrease reputation.

The action employed determines the communicative function that is used to present the ?subject and the attached ?process to the user. As above, with the Likelihood operators, these can be separated into two opposing categories: those that promote the given process and those that demote the given process with equivalent operators in each:

- Express-Likelihood-of-Outcome/Play-Down-Likelihood-of-Outcome
- Outcome-is-Fair/Outcome-is-Not-Fair
- Express-Happiness-about-Outcome/Express-Sadness-about-Outcome
- Commend-Outcome/Warn-Outcome
- Express-Worry-about-Outcome/Play-Down-Worry-about-Outcome

The actions within the Comment-on-Result category follow from the Comment-on-Outcome operators and provide the same communicative functions but with an appropriate name change (thus Express-Likelihood-of-Outcome becomes Express-Likelihood-of-Result). However, the Comment-on-Result category is a specialisation of Comment-on-Outcome and there is a corresponding specialisation of the parameters:

(Express-Likelihood-Of-Result ?origin ?process ?effect ?actor)

Where the Comment-on-Outcome category presents subjects that can apply to a range of situations (and are thus useful across a range of events) the Comment-on-Result

category provides subjects tailored to a particular event based on default reasoning in the ASM's knowledge base about that situation. As this 'default information' is specific to given events, not all events have default information attached but for those that do, the knowledge base is able to provide a more precise and distinct response. The parameters indicate the starting point for the process to be applied (?origin), details of the process applied (?process) and the resulting impact of the process upon the user (?effect). Additionally, actors identified with the user's account of their situation may be attached to the operator (?actor) to further contextualise the response to the user's situation.

For example, the operator used in Example 6.2 is:

(Express-Likelihood-Of-Result  
Event-Actualised Only-Voluntary-Redundancies Positive-Aftermath Nil)

Here the ?action attempts to communicate the likelihood that the described result will occur. This result is framed as happening after the outcome has completed (event-actualised) but providing a positive effect on the user despite the seemingly negative effect of the event completing (positive-aftermath). Thus, in Brémond's terms, the situation is presented as an amelioration process rather than a degradation process (Table 5.1). The process itself indicates the company may only ask for voluntary redundancies and thus the implication is that the user will not be at risk of being made redundant.

Alternatively, another operator that could have been used in Example 6.2 is:

(Result-Is-Fair Pre-Actualisation Find-Additional-Funding Event-Prevented Nil)

This ?action communicates that it is reasonable for the user to expect a given result, which in this case is that the event is prevented. The result here is framed as happening before the outcome has completed (pre-actualisation) with the result that the outcome will fail rather than complete (event-prevented). Thus, in Brémond's terms, the situation is presented as a protection process rather than a degradation process (Table 5.1). Meanwhile, the process indicates that the reason for the outcome being prevented is that additional funding may be found so as to make the redundancies unnecessary.

### 6.5.5. Reinforcing the argument – Comment-Process

The final stage of the Influence process, within Example 6.2, is the **Comment-Process** method (Figure 6.1) which considers influences outside of the main event and brings them into the discussion, reconciling them with the affective strategy employed. As Figure 6.4 illustrates, there are four different approaches with the approach selected depending on both the affective strategy chosen and the event influences mentioned by the user. The **Focus-on-Negative-Influences** method was chosen for Example 6.2 and presents the following operators (lines 12 to 15, Example 6.2):

- (Play-Down-Antagonist P1)
- (Promote-User-Ability)
- (Play-Down-Threat E5)
- (Play-Down-Threat E2)

As a Reassuring strategy is being used, the approach is to demote the ability of these various negative influences to impact the user and also to promote the user's own ability to resolve the situation successfully. Due to the large number of event influences within Example 6.2 (one antagonist, one helper and three threats) there is a correspondingly large number of event influences discussed here including Sarah (antagonist P1), the argument with Sarah (threat E5) and the problem of office politics (threat E2). In another situation requiring a Reassuring strategy but with no additional influences, clearly the only item that may be discussed under **Comment-Process** would be to promote the user's ability (and this may not even be mentioned given the variability of generation). As such, the **Comment-Process** method helps to scale the Companion's response based on the level of information provided by the user; low levels of information from the user lead to shorter Companion responses and high levels of information lead to longer responses.

In comparison, if the **Contrast-Actor-Influences** method was chosen (Figure 6.4) this might result in the following sub-section of plan operators:

- (Play-Down-Antagonist P1)
- (Promote-User-Ability)
- (Reassure-Helper P2)

This starts with the same operators as before, attempting to demote the role of the antagonist and promoting the user's ability, but the following operator now serves to promote the helper (Sue, who the user likes) as being beneficial to the situation. As such, across Reassuring strategies and regardless of the approach selected or the exact

breakdown of positive and negative influences, the affective strategy will entail that the negative aspects are played down and the positive aspects are promoted.

#### **6.5.6. Summarising the response – Conclusion**

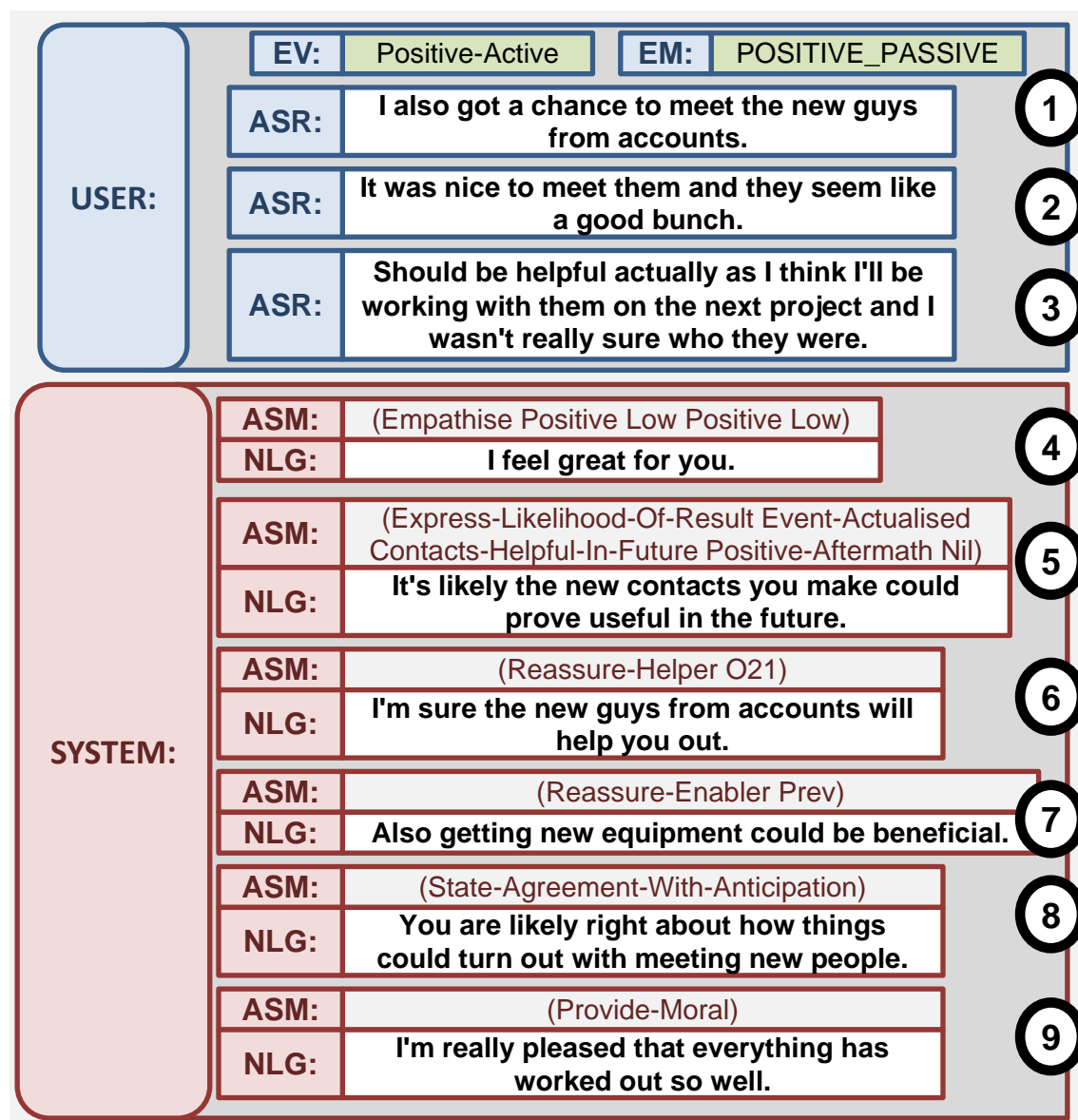
The final step in each generated plan is to provide a summary of the core message behind the selected affective strategy and this is accomplished using the Conclusion method (Figure 6.1). This consists of one operator (line 16, Example 6.2):

(Provide-Moral)

This operator provides a moral, in the style of an aphorism or maxim, which embodies the affective strategy used in the plan and therefore reinforces the influence the plan tries to relay. However, as it acts as a summary, if the overall plan (excluding the Conclusion method) is less than three utterances (and therefore there is not much to be summarised), the planner forgoes the Provide-Moral operator to keep the response short and appropriate for the amount of information provided by the user.

### **6.6. Comparing affective strategies**

The Reassuring strategy offers a clear demonstration of an influencing strategy in action, first providing a grounding of the user's current situation and then attempting to alter the user's perception of events. The difference in anticipation between user and Companion is leveraged to provide the influencing factor. However, in some situations there is no discrepancy between the user and Companion assessments of the event. Yet this does not mean there is no role for the ASM in providing a response and clearly the Companion should be able to respond in all situations rather than just those with a distinct means of influence. In such situations where the Companion considers both the user reaction and anticipation to be appropriate, the role of the Companion becomes to reinforce the appropriate aspects while providing a positive effect on the user.



**Example 6.3:** *Conversation with a Congratulatory narrative response. This is an excerpt from a full dialogue shown in Chapter 7 demonstrating the Companion employing a Congratulatory affective strategy. Reference is made to previous elements of the conversation by the Companion (line 7). The Companion starts and concludes (line 4, 8) by acknowledging the positive situation (of meeting new people) and in-between highlights some of the positive aspects of the situation (line 5, 6, 7). The Companion then finishes by summarising the strategy employed (line 9). The helper 'O21' refers to 'the new guys from accounts' (line 1) and the enabler 'Prev' refers to getting new equipment which was the main event in the previously generated narrative response.*

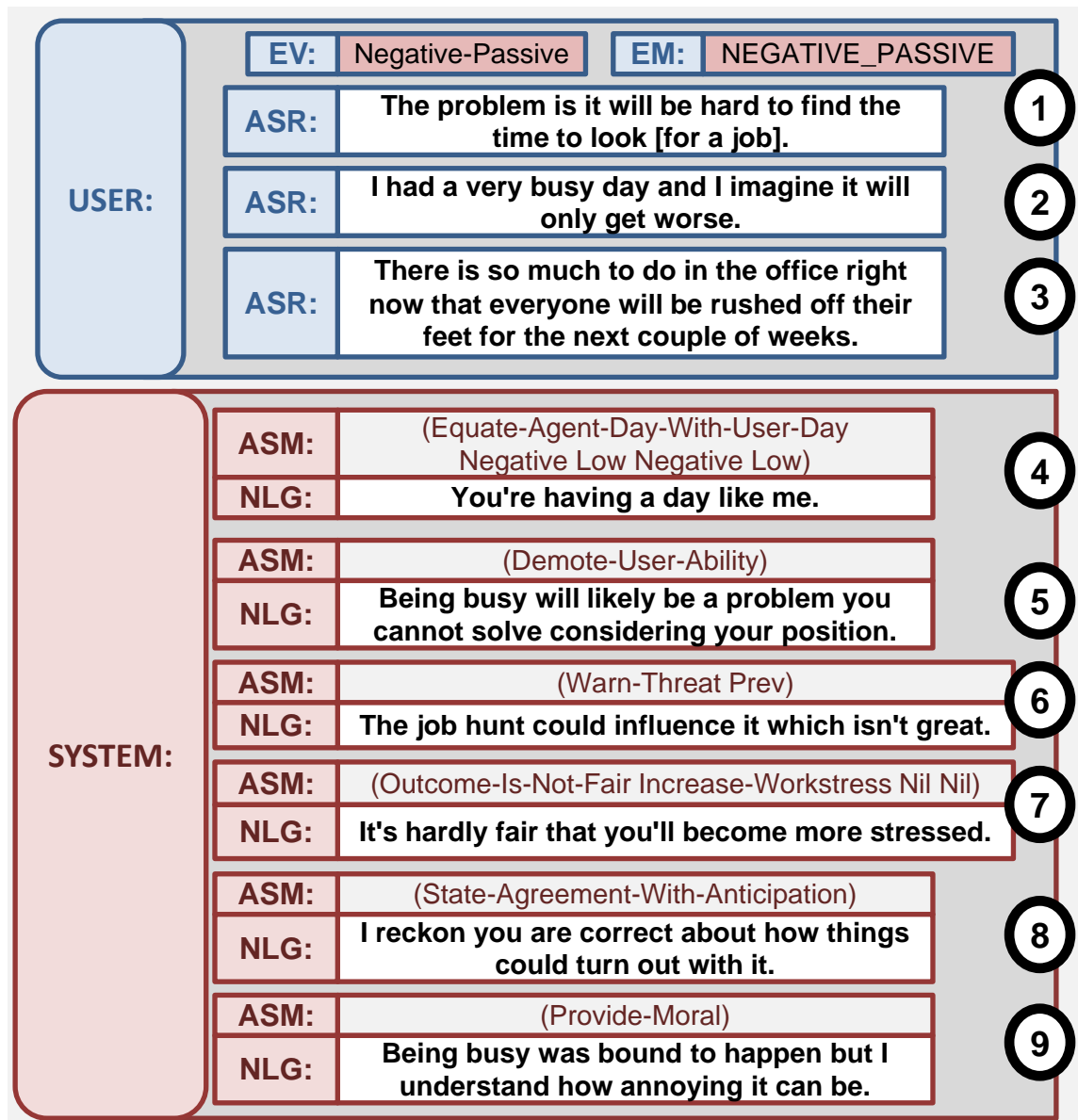
### **6.6.1. An example of a Congratulatory narrative response**

Example 6.3 presents a dialogue showing a Congratulatory strategy where both user and Companion anticipations hold that this is a positive situation and the user reaction is appropriately positive. The response from the Companion is both to acknowledge the correctness of the user's reaction (in terms of both emotional reaction and anticipation) and to further reinforce the positives aspects. This reinforcement highlights both a positive result for the user and positive influences mentioned by the user. There are no negative influences to discuss here but even if there were, they would be downplayed in order to keep the focus on the positive aspects. The tone is thus overwhelmingly positive and, though this does not involve instigating a change in attitude in the user, influence is still employed in order to support and accentuate a correct user attitude.

### **6.6.2. An example of a Sympathetic narrative response**

As a counterpoint to this, Example 6.4 shows a dialogue featuring a Sympathetic strategy. Here the anticipations of the user and Companion both point towards a detrimental situation for the user and the user reaction is appropriately negative towards this situation. As the opposite of the Congratulatory strategy, the Companion's response is to acknowledge the negative situation and reinforce the negative aspects. However, while the Congratulatory strategy seeks to emphasise the positive aspects for their own sake (and thus emphasise the positive impact upon the user), the Sympathetic strategy seeks rather to absolve the user of any blame with regards to the negative situation (and thus to still provide a positive influence). As with the Congratulatory strategy, there is no direct change in attitude to be accomplished (in terms of altering the user's anticipated outcome) though there may be an indirect change in that the user may no longer feel responsible for the negative situation. This is accomplished through reinforcing that the situation is outwith the user's control.





**Example 6.4:** *Conversation with a Sympathetic narrative response. This is an excerpt from a full dialogue shown in Chapter 7 demonstrating the Companion employing a Sympathetic affective strategy. This example makes reference to previous elements of the complete conversation by the Companion (such as line 6) and the text of the user's utterance is altered for clarity (line 1). The Companion starts by identifying with the user (line 4), attempting to diminish the user's responsibility for the situation (line 5), acknowledging the negatives aspects (line 6 and 7) and reinforcing the user's negative anticipation (line 8) before finishing by summarising the strategy employed (line 9). The threat 'Prev' refers to job hunting which was the main event in the previously generated narrative response.*

### 6.6.3. Introducing variety of expression

Across the narrative responses presented in Example 6.2, 6.3 and 6.4 can be seen some commonality in how the Companion responds to the user. Both Example 6.3 and 6.4 happen to focus on the user's anticipation (Focus-on-Anticipation decomposition of the Respond-to-User-Reaction method) and provide a response with the State-Agreement-with-Anticipation operator. Example 6.2, while providing an opposing reaction to the user's anticipation, uses the mirroring operator State-Disagreement-with-Anticipation. The Empathise operator is also used to provide a Spontaneous-Reaction decomposition in both Example 6.2 and 6.3. While some commonality is inevitable in such a system it is still desirable for the Companion to show a freshness in the reply across repeated narrative responses.

The ASM employs several measures that attempt to introduce variety in the responses to prevent the Companion's utterances from appearing overly prescribed or formulaic (and thus unnatural to the user). Variation can be seen between the different narrative responses at the Influence method level (Figure 6.1). While Example 6.2 employs an ordering of Respond-to-User-Reaction / Address-Outcome / Comment-Process, Example 6.3 presents the narrative response as Address-Outcome / Comment-Process / Respond-to-User-Reaction and Example 6.4 provides a further variation with Comment-Process / Address-Outcome / Respond-to-User-Reaction.

The decompositions of Respond-to-User-Reaction and Comment-Process offer a greater level of variability as, in addition to varying the ordering of components, the total number and the selection of individual components used in a narrative response will vary based on the strategy and event influences in effect. Even when repeatedly generating plans for the same situation (that is, with the same strategy, main event and event influences) there will be variation in the elements chosen and their respective ordering. Throughout this, the semantic tags help to maintain the focus on more prominent items. For example, given the three threats of Example 6.2 (the argument, the merger and the office politics), the selection (and total number) of threats displayed and their ordering will vary each time a plan is generated. Yet throughout this, the argument will feature most frequently of all the threats as it has the higher event ranking and hence highest threat assessment.

There is also variation available in the selection of operators. As an alternative to the Empathise operator within the Spontaneous-Reaction category, Example 6.4

employs the **Equate-Agent-Day-with-User-Day** operator (line 4). While these operators both provide the same basic function, to acknowledge the emotional reaction shown by the user and to communicate that this is appropriate, they do so in different ways. The **Empathise** operator tries to communicate that the Companion can relate to the user's situation and explicitly approves of the reaction while the **Equate-Agent-Day-with-User-Day** directly equates their situations and so implicitly approves of the emotional reaction.

This variety in operators can be seen replicated across the operator categories (Figure 6.5). For example, the **Comment-on-Situation** category provides various alternatives for how the Companion may acknowledge the appropriateness of the user's emotional reaction. The **State-Agreement-Regarding-Situation** operator (line 8, Example 6.2) explicitly provides an agreement that the given reaction is shared by the Companion. Meanwhile, the operator:

(Commend-Response-To-General-Situation Negative)

endorses the user's reaction and approach to the overall situation. Further, the operator:

(Commend-Response-To-Specific-Situation)

endorses the user's handling of the main event itself. Each of these operators is equally applicable to a strategy where the user reaction is appropriate.

As a given operator category must provide operators for a range of opposing functions, so there is also equivalence in variation between mirrored operators. For example, the **Comment-on-Anticipation** category provides operators for communicating an alignment in anticipation between user and Companion. The **State-Agreement-with-Anticipation** operator (line 8, Example 6.4) provides explicit agreement with the user's anticipated outcome while the operator:

(State-Coinciding-Agent-Anticipation)

instead highlights the shared anticipation between the user and Companion. These find equivalents for circumstances when the user and Companion anticipations do not match with the **State-Disagreement-with-Anticipation** and **State-Contrasting-Agent-Anticipation** operators. Both these equivalent operators handle the conflict between anticipations without being confrontational, as is suited to a Reassuring strategy. Additional operators within the **Comment-on-Anticipation** category provide

communicative functions which provide a greater challenge to the user and are thus appropriate for the more confrontational Cautionary strategy (discussed later).

Further, as mentioned previously, the NLG module offers an additional layer of variation in how it realises any given operator as an utterance. This variation of response at multiple levels of the generation process aims to provide a distinction between examples (to avoid repetitions and thus appear more natural to the user) even where examples may coincide. However, it is in the focal points of each strategy that the greatest distinction can be seen between plans.

#### **6.6.4. Highlighting differences in approach**

The handling of the decomposition of the **Comment-Process** method within each of the three examples discussed above highlights the difference in approach between the Reassuring, Congratulatory and Sympathetic strategies. For the Reassuring strategy in Example 6.2, attempting to persuade the user that things are not as bad as they fear results in the selection of operators such as **Play-Down-Threat** that seek to downplay the importance of these negative influences. The Congratulatory strategy of Example 6.3 seeks to focus on the positive influences and highlights those with operators such as **Reassure-Helper** and **Reassure-Enabler**. Meanwhile the Sympathetic strategy in Example 6.4 acknowledges the negative aspects with operators such as **Warn-Threat**.

Even with strategies sharing the same approach to dealing with the additional event influences, the character of the situations themselves leads towards a differentiation in the resulting plans. For example, both the Reassuring and Congratulatory strategies will seek to **Play-Down-Threat/Play-Down-Antagonist** and **Reassure-Enabler/Reassure-Helper**. However, the tendency for situations requiring a Reassuring strategy is for the additional influences to focus on the negative aspects. This is natural given the negative aspects are what the user fears will result and so this is what they talk about. Thus this results in the **Comment-Process** method focusing on **Play-Down-Threat/Play-Down-Antagonist** operators. Conversely, the tendency for situations requiring a Congratulatory strategy is for the additional influences to focus on the positive aspects. This is natural as the user is expressing their happiness about the positive nature of their situation. Thus this results in **Reassure-Enabler/Reassure-Helper** operators.

Also notable here is the difference in the handling of the user's ability to manage their situation which further accentuates each given strategy's approach. Within Example 6.2, the Reassuring strategy employs the **Promote-User-Ability** operator (line 13) in order to encourage the user in their ability to resolve the problems they face. This operator is weighted towards appearing in a Reassuring strategy as the function it provides is integral to the strategy's goals of reassuring the user. It helps the Companion build towards a proposed protection process rather than the user's anticipated degradation process (Table 5.1).

Meanwhile, the **Promote-User-Ability** operator does not appear in Example 6.3 despite being applicable to the situation. The goal of the Congratulatory strategy is to emphasise the positive aspects and thus highlight an amelioration process. Although it is true to say that the user is capable of handling the situation and that this is a positive, the function is somewhat redundant as the user already knows that they are in a good situation and does not need any further reassurance. There is no need of a protection process as the user anticipates an amelioration process and so the function provided does not further the goals of the Congratulatory strategy. Thus the **Promote-User-Ability** operator is weighted towards not appearing in a Congratulatory strategy.

The **Demote-User-Ability** operator (line 5, Example 6.4) provides a similar function in Example 6.4 as the **Promote-User-Ability** operator does within the Reassuring strategy. Rather than intimating that the user does not have the ability to handle the situation, however, the nuance is more that the situation is outwith their control. This distinction is important as the Companion seeks to provide a positive influence to every situation, even one with an anticipated negative outcome for the user. Even in the face of a deterioration event for the user, the operator thus becomes a reassurance that the negative outcome is undeserved.

The **Address-Outcome** method further shows the outworking of each strategy's approach within the generated plan. The operator used in Example 6.2 is:

(Express-Likelihood-Of-Result  
Event-Actualised Only-Voluntary-Redundancies Positive-Aftermath Nil)

which promotes a positive outcome for the user (through promoting a positive aftermath that supercedes the anticipated negative outcome) while the alternative outcome operator (mentioned earlier in this chapter):

(Result-Is-Fair Pre-Actualisation Find-Additional-Funding Event-Prevented Nil)

promotes a protection process as being a reasonable belief. Both these operators reinforce the positive outcome anticipated by the Companion and thus detract from the threat of a negative outcome anticipated by the user. Alternatively, the Companion can address the user's anticipated negative outcome directly with operators such as **Play-Down-Likelihood-of-Outcome** and **Play-Down-Worry-About-Outcome** which attempt to minimise the threat presented by this negative outcome. Hence the Reassuring strategy follows the pattern of trying to maximise the positive aspects and minimise the negative aspects.

In Example 6.3, the outcome operator (line 5):

(Express-Likelihood-Of-Result  
Event-Actualised Contacts-Helpful-In-Future Positive-Aftermath Nil)

also promotes a positive outcome for the user, showing a positive aftermath which reinforces the overall positive nature of the situation for the user. Alternatively, operators such as **Outcome-Is-Fair** and **Commend-Outcome** suggest that it would be reasonable to expect a given outcome and that the Companion can envisage a given outcome occurring (respectively). The Companion may also use the **Express-Happiness-About-Outcome** operator to assert a positive emotional response to the outcome and therefore also to imply that it is likely to occur. Thus the Congratulatory strategy provides a firm focus on a positive outcome for the user.

In Example 6.4, the outcome operator (line 7, Example 6.4):

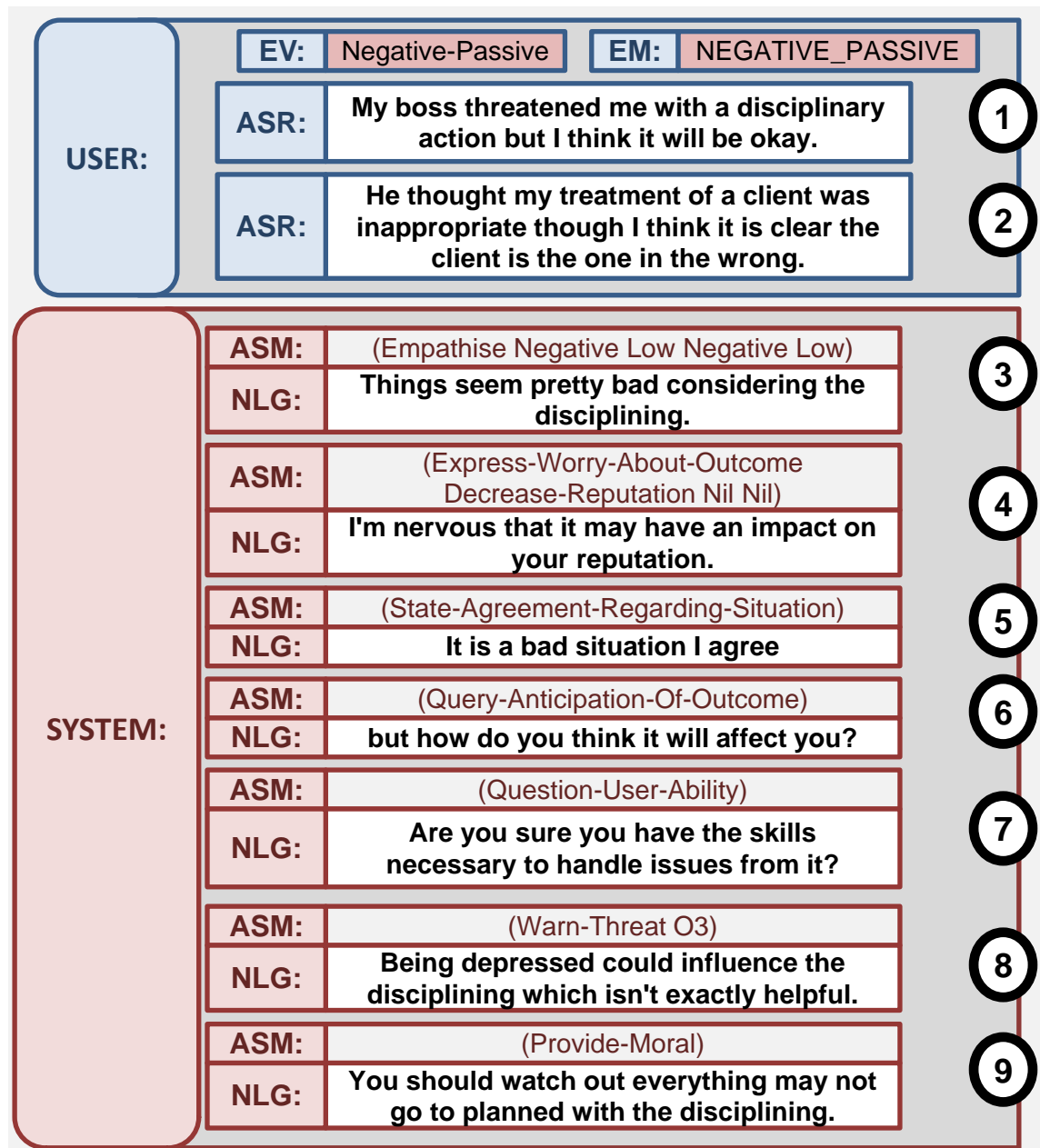
(Outcome-Is-Not-Fair Increase-Workstress Nil Nil)

acknowledges a negative outcome but frames this as an unfair development. This contributes to the goal of the Sympathetic strategy that a negative outcome, though inevitable, is not deserved by the user. Alternatively, the operator **Express-Sadness-About-Outcome** may provide a further opportunity for the Companion to empathise with the user over the negative outcome.

#### **6.6.5. An example of a Cautionary narrative response**

Returning to a situation where the Companion and user anticipations for the main event clash, the Cautionary strategy (Example 6.5) covers those situations that mirror a Reassuring strategy. As with the Reassuring strategy the main point of influence is the user's anticipation of the eventual outcome: the user holds a positive view on the event outcome while the Companion has a negative view. Hence the Companion is attempting to caution the user that their anticipated positive outcome may actually be a negative outcome. However, rather than being a complete mirror of the Reassuring strategy (which would effectively act to demoralise the user), the Companion is still attempting to provide a positive influence. Thus, instead of demoting the user's ability to handle the situation (as with the Sympathetic strategy) and implying that they are powerless to prevent a negative outcome, the approach is rather to question the user's ability such that the user themselves will question their course of action and alter this course towards a positive outcome.

This is most clearly seen with the **Question-User-Ability** operator (line 7, Example 6.5) within the **Comment-Process** method decomposition. This operator is the literal outworking of the Cautionary strategy's approach and, rather than offering a direct commentary on the user's ability as with the **Promote-User-Ability/Demote-User-Ability** operators, merely questions the user's ability. The implication is provided in this questioning that the user will not be able to attain the positive outcome that they envisage. The rest of the **Comment-Process** method decomposition supports this by highlighting the dangers the user may face, as with the **Warn-Threat** operator (line 8), and encouraging the user to make use of any positive influences with **Commend-Enabler/Commend-Helper** operators.



**Example 6.5:** *Conversation with a Cautionary narrative response. This is an excerpt from a full dialogue shown in Chapter 7 demonstrating the Companion employing a Cautionary affective strategy. Reference is made to previous elements of the conversation by the Companion (line 8). Here the Companion acknowledges the negative situation (line 3 and 5) and goes on to challenge the user's anticipation (line 6 and 7). The Companion cites a negative outcome (line 4), references a potential problem (line 8) and concludes with a cautionary comment to summarise the strategy used (line 9). The threat 'O3' refers to the user stating they were feeling sad earlier in the dialogue.*

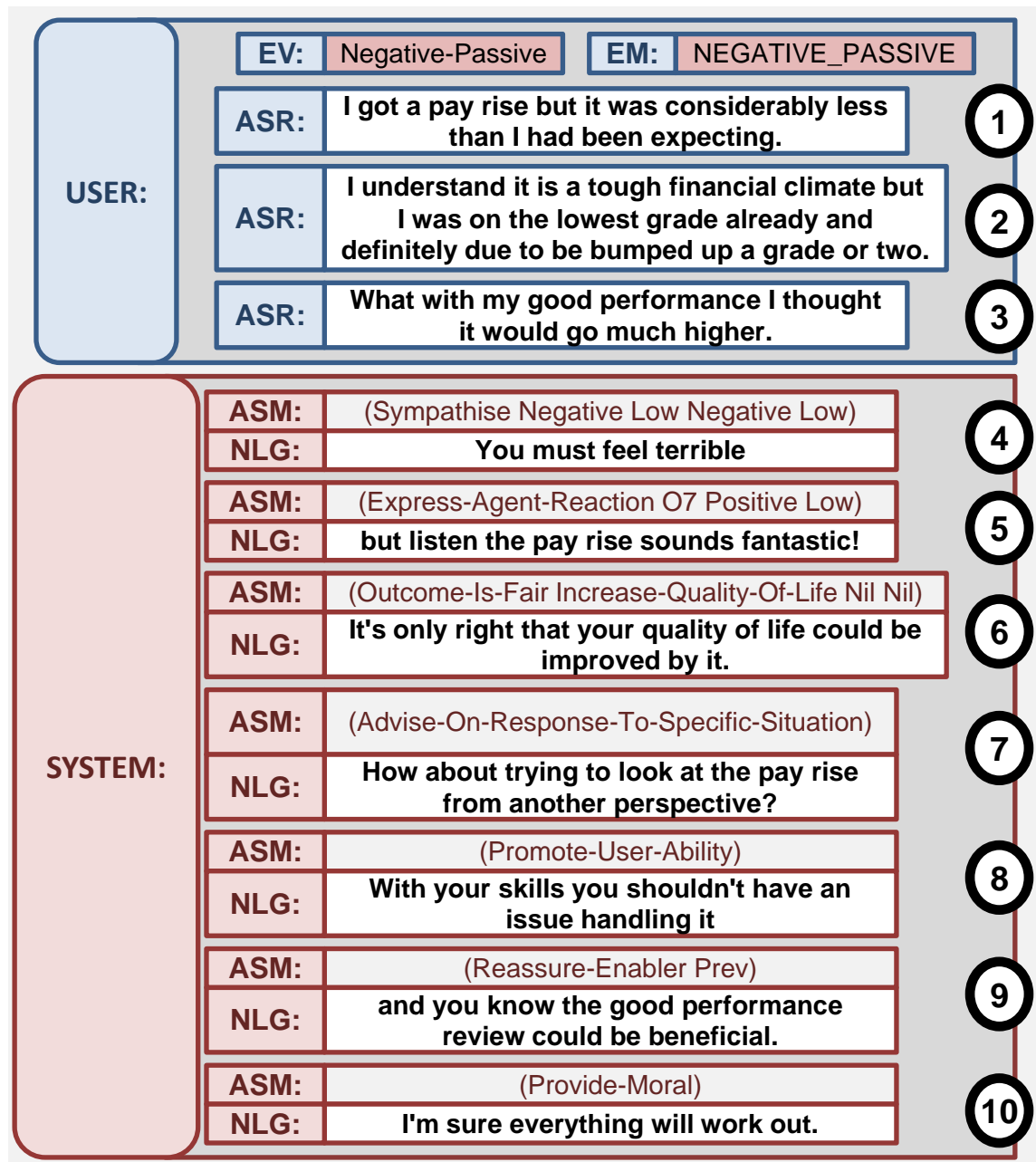


As alluded to earlier, the **Comment-on-Anticipation** category provides operators in a similar vein that serve to question the user's anticipation rather than offering a specific stance for or against it. The **Query-Anticipation-of-Outcome** operator (line 6) directly questions the user about their anticipated outcome. Alternatively, the **Advise-on-Anticipation-of-Outcome** operator challenges the user's anticipation (without providing the Companion's stance explicitly). The **State-Disagreement-with-Anticipation/State-Contrasting-Agent-Anticipation** operators are also applicable in this situation (as the Companion does not agree with the user's anticipation) but the Cautionary strategy weights towards the **Query-Anticipation-of-Outcome/Advise-on-Anticipation-of-Outcome** operators as these are more suitable for the form of influence the Cautionary strategy seeks to present.

The decomposition of the **Address-Outcome** method further attempts to reinforce this challenge to the user's anticipated outcome by highlighting the negative outcome anticipated by the Companion. The **Express-Worry-About-Outcome** operator (line 4) asserts that the Companion is worried about the given outcome occurring and thus suggests the Companion's anticipation is a real possibility. The alternatives **Express-Likelihood-of-Outcome** and **Express-Sadness-About-Outcome** also serve to promote the occurrence of a negative outcome for the user. Further, the operator **Warn-About-Outcome** offers an explicit warning of the anticipated negative outcome.

#### **6.6.6. Examples of Encouraging and Warning narrative responses**

The final two strategies employed by the ASM are similar in form to two of those already discussed: the Encouraging strategy follows the Reassuring strategy while the Warning strategy follows the Cautionary strategy. What distinguishes these two new strategies from the two previously described is that the focal point for the Companion's influence is not the anticipation of the user but the user's emotional reaction. Indeed the Encouraging and Warning strategies may cover situations both where the Companion and user anticipation's match and where they do not (Table 5.3). Any issues with the user's anticipation thus become of secondary concern to addressing the inappropriate emotional reaction shown by the user. This manifests itself in an increased use of emotion in the generated response with the Companion employing affective operators in order to highlight an appropriate emotional reaction.



**Example 6.6:** *Conversation with an Encouraging narrative response. This is an excerpt from a full dialogue shown in Chapter 7 demonstrating the Companion employing an Encouraging affective strategy. The Companion begins by acknowledging the user's emotional reaction (line 4) but then presents a contrasting reaction (line 5). The Companion highlights positives (line 6 and 9), promotes the user's ability to manage the situation (line 8) and prompts the user to examine their viewpoint (line 7). The conclusion provides a positive summary of the situation (line 10). The Express-Agent-Reaction operator (line 5) is targeted at the user's pay rise ('O7') which is the main event. The enabler 'Prev' refers to the performance review that was the main event in the previous narrative response.*

Example 6.6 shows a dialogue featuring an Encouraging strategy. The commonality with the Reassuring strategy can be seen in the approach of the **Comment-Process** method which also seeks to promote the positive aspects, such as with the **Reassure-Enabler** operator (line 9), and to demote the negative aspects with such operators as **Play-Down-Threat**. Further, the **Promote-User-Ability** operator is again used to reinforce the user's ability in obtaining a positive outcome. The **Address-Outcome** method also responds in a similar way to a Reassuring strategy with operators such as **Outcome-Is-Fair** (line 6) and **Express-Likelihood-Of-Outcome** used to highlight positives and operators such as **Play-Down-Likelihood-Of-Outcome** and **Play-Down-Worry-About-Outcome** to downplay the negatives.

However, the disagreement with the user's anticipation (in a Reassuring strategy) is now replaced by disagreement with the user's emotional reaction (in an Encouraging strategy). This takes the form of **Advise-On-Response-To-Specific-Situation** (line 7) and **State-Disagreement-Regarding-Situation** operators. The first of these suggests the user reappraise their evaluation of their situation (specifically towards the main event) while the latter provides an outright disagreement with the user's evaluation.

Similarly, Example 6.7 presents a dialogue utilising a Warning strategy which shares aspects of a Cautionary strategy. The operators **Question-User-Ability** (line 10), **Warn-Threat** (line 11) and **Warn-Antagonist** (line 12) replicate the approach of challenging the user and highlighting negative influences used by a Cautionary strategy. A Warning strategy will likewise seek to **Commend-Enabler/Commend-Helper** to promote the use of positive influences as with a Cautionary strategy. The **Address-Outcome** method also employs the same operators as in a Cautionary strategy such as **Warn-About-Outcome**, **Express-Likelihood-Of-Outcome** and **Express-Worry-About-Outcome** to highlight the negative situation.

Yet the approach of questioning the user's anticipation (used in the Cautionary strategy) is now applied to questioning the user's emotional reaction within the Warning strategy. Thus operators such as **Query-Response-To-General-Situation** (line 8) and **Advise-On-Response-To-Specific-Situation** provide a challenge to the user with the intent of persuading them to re-evaluate their emotional reaction.

USER:	EV:	Positive-Active	EM:	POSITIVE_ACTIVE	
	ASR:	It was really amusing though.			1
	ASR:	John and Dave had an argument in the middle of the office and I had to try really hard not to laugh out loud.			2
	ASR:	I hate John, he has such an inflated image of himself.			3
	ASR:	We used to say that he always took so long to enter a room because he has to let his ego go in first since they both wouldn't fit through the door.			4
	ASR:	And Dave really took him down a notch because John was just talking rubbish in front of everyone and Dave just tore his argument apart.			5
SYSTEM:	ASR:	John didn't know what to say in response so he just walked out.			6
	ASM:	(Calm-Down-User Positive High Positive High)			7
	NLG:	You should try to not get ahead of yourself.			
	ASM:	(Query-Response-To-General-Situation Positive)			8
	NLG:	Perhaps you should take a look at the situation from another angle?			
	ASM:	(Express-Agent-Emotion Hate O10 True)			9
	NLG:	Personally I absolutely hate arguments!			
	ASM:	(Question-User-Ability)			10
	NLG:	Are you sure you have the skills necessary to handle the effects arising from their argument?			
	ASM:	(Warn-Threat Prev)			11
	NLG:	The gossip might influence the argument which isn't great.			
	ASM:	(Warn-Antagonist O9)			12
	NLG:	Also be careful as John could make trouble for you.			
	ASM:	(Play-Down-Likelihood-Of-Outcome Conserve-Colleague-Relations Person O9)			13
	NLG:	It's doubtful that your relationship with John won't be affected.			
	ASM:	(Provide-Moral)			14
	NLG:	It worries me that things may not work out with their argument.			

**Example 6.7:** *Conversation with a Warning narrative response. This is an excerpt from a full dialogue shown in Chapter 7 demonstrating the Companion employing a Warning affective strategy. The Companion refers to previous elements of the dialogue (line 11). The Companion starts by attempting to moderate the user's emotional reaction (line 7), providing an alternative response (line 9) and questioning both the user's approach to (line 8) and ability to handle (line 10) the situation. The Companion then goes on to highlight negative aspects (line 11 and 12) culminating in a negative outcome (line 13). The Companion then expresses further concern in the summary of the strategy (line 14). The Companion expresses hatred (line 9) for the argument ('O10') which is the main event. The threat 'Prev' refers to gossip in the office that was the main event of the previous narrative response. The antagonist 'O9' refers to John, whom the user dislikes, and this is referenced in both a warning (line 12) and the outcome (line 14).*

The user's emotional reaction is thus the crux of the Encouraging and Warning strategies and its importance is shown in the impact upon the Spontaneous-Reaction category of operator. While the default response in previous strategies was to Empathise with the user, this response is now to Sympathise (line 4, Example 6.6) with the user. This still performs the function of acknowledging the user's reaction but the extra function of endorsing the reaction is no longer present. As the Companion no longer shares the user's emotional reaction it is important to distinguish between recognising the user's affective state and approving of that reaction in order to ensure cohesion with later parts of the plan where the user's reaction will then be challenged.

The Spontaneous-Reaction category also includes the operator Calm-Down-User (line 7, Example 6.7) which provides a very specific function. This operator carries the pre-condition that the arousal of the user's emotional reaction is identified as high (hence the emotional state returned from the Emotional Model will be either negative-active, meaning the user is angry, or positive-active, meaning the user is very excited). This operator serves both to acknowledge the user's reaction, including the high arousal, and to then attempt to moderate that high arousal. This operator is weighted towards being selected with either Cautionary or Warning strategies, as this fits with these strategies' approach of challenging the user, and for emotional reactions that are judged to be inappropriate, as the emotional reaction requires challenging.

The final consequence of the user's emotional reaction being judged as inappropriate is seen in a greater affective response from the Companion than with appropriate user reactions. This affective response is controlled by operators of the **Express-Agent-Attitude** category which has already been touched on previously. This category consists of the operators **Express-Agent-Opinion** (line 10, Example 6.2), **Express-Agent-Reaction** (line 5, Example 6.6) and **Express-Agent-Emotion** (line 9, Example 6.7). Each of these operators requires a target which will normally be the main event but may also be an appropriate event influence. The operator then serves to present an emotional reaction from the Companion regarding that target which will serve to make it clear to the user what the Companion regards as an appropriate emotional reaction.

Each of the **Express-Agent-Attitude** operators provides a different variation in how the affective response is provided. The operator:

(Express-Agent-Opinion ?target ?valence)

provides a statement that the given ?target is either good or bad, depending on the value of ?valence (as either positive or negative). Meanwhile, the operator:

(Express-Agent-Reaction ?target ?valence ?arousal)

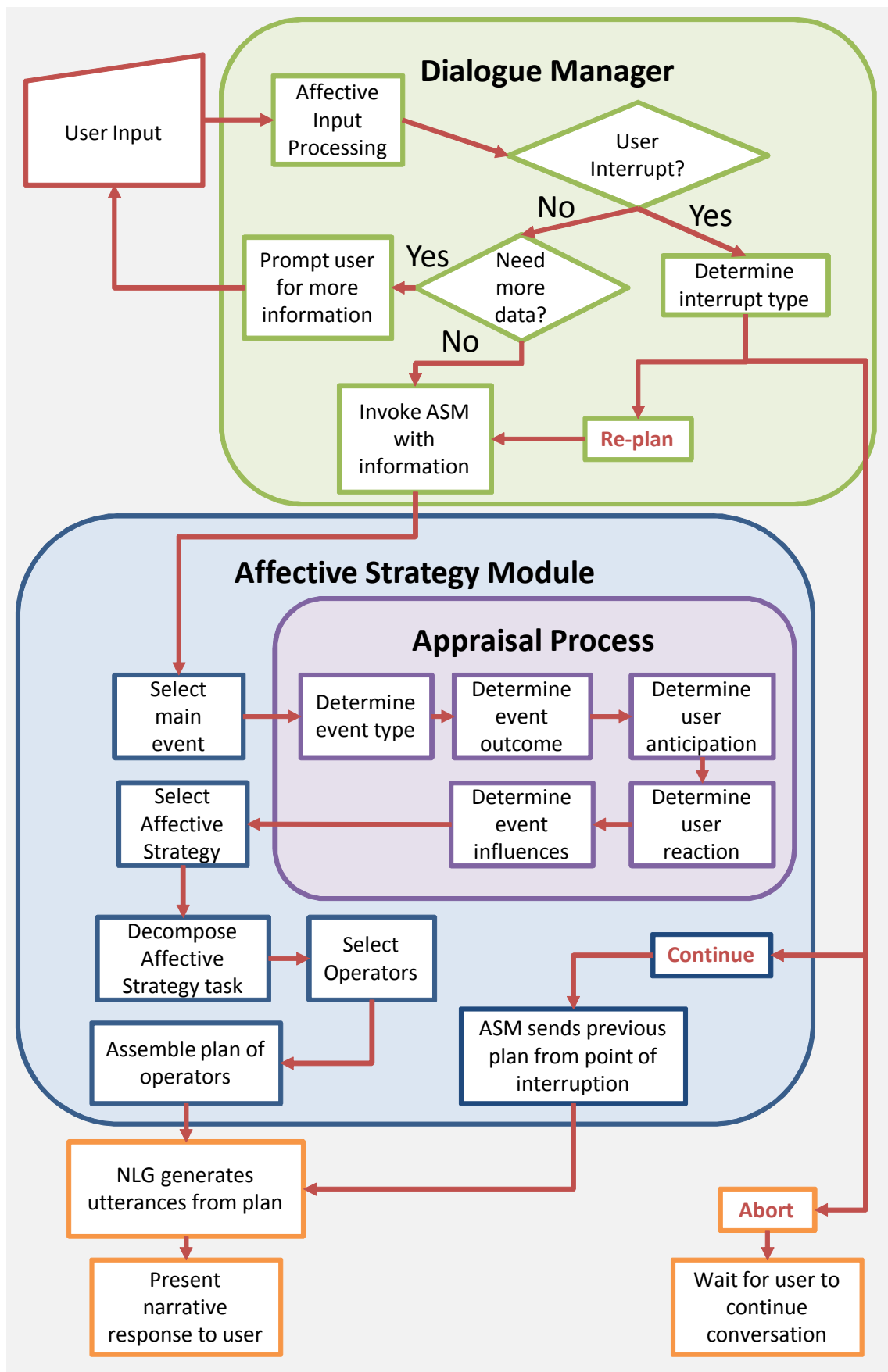
provides a reaction to the ?target given the emotional parameters of ?valence and ?arousal. Thus the ?valence determines whether the reaction is positive or negative, and the ?arousal determines the level of excitement shown by the response. Finally:

(Express-Agent-Emotion ?target ?emotion ?matches-user-emotion)

provides a statement of how the Companion feels about the ?target, with the feeling dictated by the ?emotion (and ?matches-user-emotion providing a Boolean value indicating whether this feeling is shared by the user). The emotions include basic responses such as liking, disliking, loving or hating the target.

## 6.7. Summary of the ASM process

Figure 6.6 provides a flowchart summarising the process followed by the ASM in producing a narrative response. This includes details of the DM invoking the ASM, the appraisal process carried out by the ASM and the compositional approach used in generating the plan for the narrative response.



**Figure 6.6:** Summary of the process of generating a plan for the narrative response.

## **6.8. Conclusion**

This chapter has discussed the use of an HTN Planner by the ASM in the generation of a plan of operators for a narrative response. The composition of the plan and the selection of individual operators have been discussed including details of the range of operators and their respective functions. Dialogue excerpts for each of the affective strategies have presented the various dialogue phenomena and these have also been discussed. Thus this chapter has completed discussion of the full implementation of the ASM. The next chapter will step back from this detailed examination of the ASM and instead examine the place of a narrative response within the wider context of a complete conversation. It will consider this by making use of dialogues gathered from the completed HWYD Companion.



## 7. Results



**Figure 7.1:** *The HWYD Companion at ICT 2010. Here Prof. Stephen Pulman, from the University of Oxford, demonstrates the HWYD Companion to Euronews at the ICT 2010 Conference.*<sup>13</sup>

### 7.1. Introduction

This research has presented the HWYD Companion, the final prototype of the COMPANIONS project. The Companion has been fully implemented and is capable of demonstrating conversational dialogue meeting the objectives previously set out: processing longer utterances than typical task-oriented dialogues, detecting and processing the affective aspects of communication, providing dialogue management (including handling user interruptions and providing a timely response) and returning a narrative system response. Indeed, the HWYD Companion has been demonstrated at a range of venues including the 9<sup>th</sup> International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2010)<sup>14</sup> and the ICT 2010 Conference in Brussels (see Figure 7.1). Each of these demonstrations has seen a human demonstrator conversing with the HWYD Companion for extended dialogues.

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<sup>13</sup> Photo by Raúl Santos de la Cámara. Used with permission.

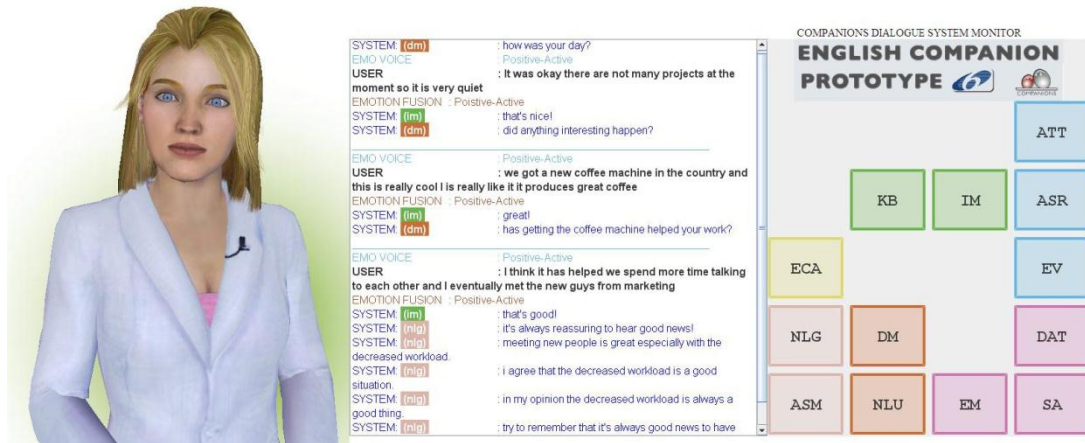
<sup>14</sup> Where it was awarded the Best Demo Prize.

This chapter will focus on extended dialogues produced by the completed HWYD Companion in order to assess the contribution made to conversational dialogue both by the HWYD Companion and the ASM. This assessment will be made with reference to the challenges of conversational dialogue set out at the end of Chapter 4. However, before this, details of the demonstration and testing of the completed HWYD Companion will be discussed.

## **7.2. Demonstrating the HWYD Companion**

The Companion is not fully speaker independent which makes it impractical to allow general public access to the system during demonstrations. Both the EmoVoice and ASR components require training with a user's voice (for around 10 to 15 minutes for each component) in order to function correctly. Due to this requirement a human demonstrator, from a small team of people trained with the system, engages in conversation with the Companion. In order to illustrate the Companion's ability to handle real conversations these demonstrations are not scripted; each demonstrator is familiar with the Companion's concept, knowing the range of topics covered by the system and what information the system is looking for, but does not follow a set pattern either in terms of wording or events to be discussed. Further, the audience is given the opportunity to indirectly influence the conversation by suggesting the topics and manner of response for the human demonstrator's utterances.

A demonstration (e.g. Example 7.1 below) starts with the Companion asking "How was your day?" leaving the demonstrator to discuss events from their working day in free conversation. The demonstrator aims to cover a range of situations featuring variety in both the events discussed and the emotions shown. The demonstrator will also show variety in the length of response from extended accounts spanning multiple lines of ASR input to shorter utterances which will lead the Companion to prompt for further information. The demonstrator will typically provide enough information within each conversation for four or five narrative responses from the Companion. Further, the demonstrator may interrupt narrative responses to exhibit the Companion's interruption handling (Crook et al, 2012).



**Figure 7.2:** Screenshot of the HWYD Companion

### 7.3. Testing the HWYD Companion

The HWYD Companion has also undergone several stages of user testing. The setup used for both demonstrations and user testing involves the use of a headset microphone to capture the speech input with a large monitor used for displaying the ECA, conversation transcript and details of module processing (see Figure 7.2). The testing requires volunteers train the system (namely adapting ASR and EmoVoice for their speech profiles) before conversing with the Companion over multiple dialogues covering different scenarios (within the office work domain). For example, the evaluation covered in (Smith et al, 2011) features seven scenarios designed to test the full range of the Companion's conversational ability. Five of these scenarios (A to E) involve set conversations, where the volunteers are given directions on the events and emotional state they should convey but are left to employ their own wording of these situations. This ensures coverage of a range of topics and affective states (and thus also that a range of affective strategies are employed) without bias to the language employed. The remaining two scenarios (F and G) focus on free-form conversations where the content and style of the conversation are left entirely to the volunteer; the first free-form scenario (F) starts with an equivalent to scenario A in order to prime the user while the second free-form scenario (G) is entirely user-defined. These allow testing without bias towards topics or their affective context.

## **7.4. Examples of extended dialogues with the HWYD Companion**

While previous chapters have examined the theory and mechanics behind the design of the ASM, the rest of this chapter seeks to illustrate the outworking of these features within real dialogues. This will consist of providing analysis within the context of full, real world conversations between user and Companion rather than focusing on particular ASM plans in a given dialogue. To this end I will be mainly presenting extended dialogues between user and Companion and discussing the overall flow and interplay of features within them.

### **7.4.1. An extended dialogue from the ICT 2010 Conference**

The first extended dialogue to be presented, Example 7.1 (next page), is taken from the demonstrations at the ICT 2010 Conference and shows that the Companion is able to maintain a full discussion with the user encompassing repeated DM and ASM output across multiple turns.

The conversation in Example 7.1 is of moderate length at 34 dialogue turns and includes four narrative responses generated by the ASM. The length places it in the range of the previous human-human conversational dialogues shown, fitting in between the longer Santa Barbara corpus excerpt and the shorter counselling dialogue. This is similar to the human-human dialogue of the TRAINS corpus and two or more times the length of the human-computer task-oriented dialogues of TRAINS and HMIHY. There is also a moderate utterance length with user utterances averaging 11 words per utterance and system utterances around 7 words (8 ignoring the ‘short loop’ feedback). Thus while shorter than the lengthy utterances of the counselling dialogue, the user utterances here still exceed the typical length of the task-oriented dialogues. This shows that the HWYD Companion is capable of dialogues of a non-trivial length and features user utterances longer than typical task-oriented dialogue systems.

USER:	EV: Negative-Active	EM: NEGATIVE_ACTIVE	1
	ASR: Good afternoon, Matilda.		
SYSTEM:	DM: Hello Steve, how was your day?		2
USER:	EV: Negative-Active	EM: NEGATIVE_ACTIVE	3
	ASR: My day started out very badly.		
SYSTEM:	DM: Please tell me.		4
USER:	EV: Neutral	EM: NEGATIVE_ACTIVE	5
	ASR: I got stuck in traffic going to work I missed an important meeting.		
SYSTEM:	ASM: (Empathise Negative Low Negative Low)		6
	NLG: I have been through similar problems.		
	ASM: (Commend-Response-To-General-Situation Negative)		7
	NLG: The situation isn't great but I think you will be fine.		
USER:	EV: Neutral	EM: NEGATIVE_ACTIVE	8
	ASR: And after that I had a disaster this afternoon when my computer crashed.		
SYSTEM:	IM: Okay.		9
	DM: What are you working on?		10
USER:	EV: Positive-Passive	EM: NEGATIVE_ACTIVE	11
	ASR: And I were working on an important presentation.		
	Actual: (I was working on an important presentation.)		
SYSTEM:	ASM: (Empathise Negative Low Negative Low)		12
	NLG: Try not to worry.		
	ASM: (Commend-Response-To-General-Situation Negative)		13
	NLG: The situation isn't great but I'm sure you will be able to handle things.		

SYSTEM:	ASM:	(Express-Agent-Reaction O12 Negative High)	14
	NLG:	The technical problems were bound to happen!	
	ASM:	(Provide-Moral)	15
	NLG:	I can understand how you feel but unfortunately the technical problems were bound to happen.	

USER:	EV:	Neutral	EM:	POSITIVE_ACTIVE	16
	ASR:	That if the presentation of the success lighting my boss will be.			
	Actual:	(If the presentation isn't a success it's likely my boss will be very angry.)			

SYSTEM:	DM:	Why did this happen?	17
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USER:	EV:	Neutral	EM:	NEUTRAL	18
	ASR:	I think it's because the technical maintenance people didn't install the update is properly.			
	Actual:	(I think it's because the technical maintenance people didn't install the updates properly.)			

SYSTEM:	IM:	Oh.	19
	DM:	extra_mmm! [paralinguistic event for TTS]	

USER:	EV:	Neutral	EM:	NEUTRAL	21
	ASR:	I'd anything that John does his dark job are it at all conscientiously.			
	Actual:	(If anything it's that John doesn't do his day job at all conscientiously.)			

SYSTEM:	ASM:	(Empathise Negative Low Negative Low)	22
	NLG:	I know what you are going through.	

USER:	EV:	Neutral	EM:	NEUTRAL	23
	ASR:	While thank you Matilda if the presentation isn't successful I think the boss will probably try to fire me.			
	Actual:	(Why thank you, Matilda. If the presentation isn't successful I think the boss will probably try to fire me.)			

SYSTEM:	IM:	I understand.	24
	DM:	How likely is it that you will be made redundant?	25
USER:	EV:	Positive-Passive	26
	EM:	POSITIVE_ACTIVE	
	ASR:	That depends if the presentation is a success I think ahhh be okay.	
	Actual:	(That depends on if the presentation is a success. I think I'll be okay.)	
SYSTEM:	DM:	Which project is that?	27
USER:	EV:	Positive-Active	28
	EM:	POSITIVE_ACTIVE	
	ASR:	That's the companions project.	
SYSTEM:	IM:	Is that so.	29
	ASM:	(Calm-Down-User Positive High Positive High)	30
	NLG:	You should try to not get too excited.	
	ASM:	(Play-Down-Likelihood-Of-Outcome Conserve-Motivation Nil Nil)	31
	NLG:	It's doubtful that your motivation won't change because of the redundancies	
	ASM:	(Query-Response-To-General-Situation Positive)	32
	NLG:	Don't take it too personally look at them from a different perspective.	
	ASM:	(Express-Agent-Emotion Hate O20 True)	33
	NLG:	Personally I would hate having to go through office redundancies!	
	ASM:	(Provide-Moral)	34
	NLG:	It's obvious that the consequences of redundancies are likely to be bad.	

**Example 7.1:** An extended dialogue from ICT 2010. This is a full conversation between a human demonstrator and the HWYD Companion held during the demonstrations at the ICT 2010 Conference. Line 20 shows a paralinguistic event tag which invokes a backchannel audio prompt from the Text-to-Speech component designed to function as a continuer.

The conversational goals for the Companion are balanced between obtaining information on the events (and corresponding affect) experienced by the user and providing an appropriate response acting on that information. This is illustrated in Example 7.1 as the Companion alternates between prompts for information and narrative responses dealing with the information provided. The example is initiated by the user (line 1) and the system starts the conversation by soliciting details from the user about their day (lines 2 and 4). The primary impact of the initial user utterances is to provide the user's emotional state; EmoVoice recognises a **Negative-Active** emotion for the two user utterances (lines 1 and 3) equivalent to the user exhibiting anger. This is reinforced by the recognition of a **bad day** event and the corresponding negative sentiment recognised by the SA module for this utterance. With prompting the user then provides further details (line 5) which are recognised by the NLU module as events of being stuck in traffic and missing a meeting. While EmoVoice returns a **Neutral** response to this utterance, the previous **Negative-Active** responses and the negative sentiment from SA maintain the **Negative-Active** value from the EM.

Having obtained details of the user's situation the DM invokes the ASM to provide a short narrative response (lines 6 and 7) passing the ASM the initial **bad day** event. This **bad day** event is met by a Sympathetic strategy which seeks to acknowledge the negative situation and the user's negative reaction. Thus the ASM's response is to empathise with the user's situation (line 6) and to reinforce their response to this situation (in terms of a negative affect) as appropriate (line 7). Given the very general nature of the **bad day** event there is no discussion of any event outcomes and no additional influences to discuss. As the overall response just consists of two utterances a final summary is not included either.

The cycle of information gathering and response continues with the Companion alternating between prompts for further details (lines 10, 17, 20, 25 and 27) and responses to the information provided (lines 12 to 15, 22 and 29 to 34). The user's computer crash (line 8), recognised as a **technical problem** event, prompts the next narrative response (lines 12 to 15). This again employs a Sympathetic strategy as the user's behaviour is considered appropriate based on the user's emotional reaction and anticipated outcome (with the outcome certain given that the user is discussing events that have already occurred). Thus there is no attempt at persuasion and the Sympathetic strategy is focused on affirming the user in both the negative position experienced and



their response to that position. The Companion empathises with the user (line 12), commends their response to the situation (line 13), exhibits a negative emotional reaction to the technical problems (line 14) and concludes by attempting to reinforce both empathy for the user's position and that the user is not responsible (line 15).

In gathering information on the user's situation it can therefore be seen that both the event and affective information are crucial to the ASM's response. In order to provide a response consistent with the user's actual replies, the system is therefore required to provide a level of robustness in dealing with incorrectly recognised inputs. The Companion is able to provide this robustness through a combination of solutions. The temporal integration provided by the EM will filter out inconsistent emotional readings (such as in lines 5 and 7). Likewise when the Companion is not provided with, or is not able to recognise, event information the DM will seek additional information from the user. Indeed, the intermediate section of the example is replete with prompts from the Companion (lines 17, 20, 25, 27) as the system is not able to determine many events to discuss. Further, the NLU module is not dependent on a complete grammatical structure within user utterances. The information extraction techniques employed are able to identify an event concerning a potential **redundancy** (line 23) despite a long and complex result from the ASR. Incomplete information can then be used by the DM to solicit missing details. For example, the **redundancy** event is used in a prompt for further information (line 25).

The final narrative response (lines 30 to 34) responds to this with a Warning strategy. Here the ASM focuses on the potential **redundancy** event and attempts to challenge the **Positive-Active** emotional response shown by the user towards it. This consists of individually challenging the intensity of the reaction (line 30), the effect on the user's motivation (line 31) and the appropriateness of the reaction itself (line 32). The Companion then provides a more appropriate reaction, namely hating redundancies (line 33) and reinforces that redundancies are bad in the summary (line 34).

This narrative response is appropriate given the information provided to the ASM. However, with the user actually providing a negative emotional reaction (which was misunderstood by EmoVoice as neutral or positive), such a response is quite inappropriate and likely to cause confusion. Thus the performance of the Companion in providing an appropriate response is naturally dependent not only on processing that input correctly but also on attaining the correct input to start with.

Given this dependency and the fact that the current focus is on the role of the ASM within the overall system and not on the system itself, I have elected to present further examples with the assumption of ‘perfect input’ from the ASR and affective input components. These examples still represent actual output from the system rather than theoretical behaviour but, instead of relying on the ideal performance of the ASR and the affective components, I have opted to provide text-based input including manually specifying the affective results<sup>15</sup>. Subsequent to this, the system executes as normal with the NLU/DM processing the input, invoking the ASM as it deems appropriate with the ASM passing its results to the NLG module for realisation as text, as with the full integrated system.

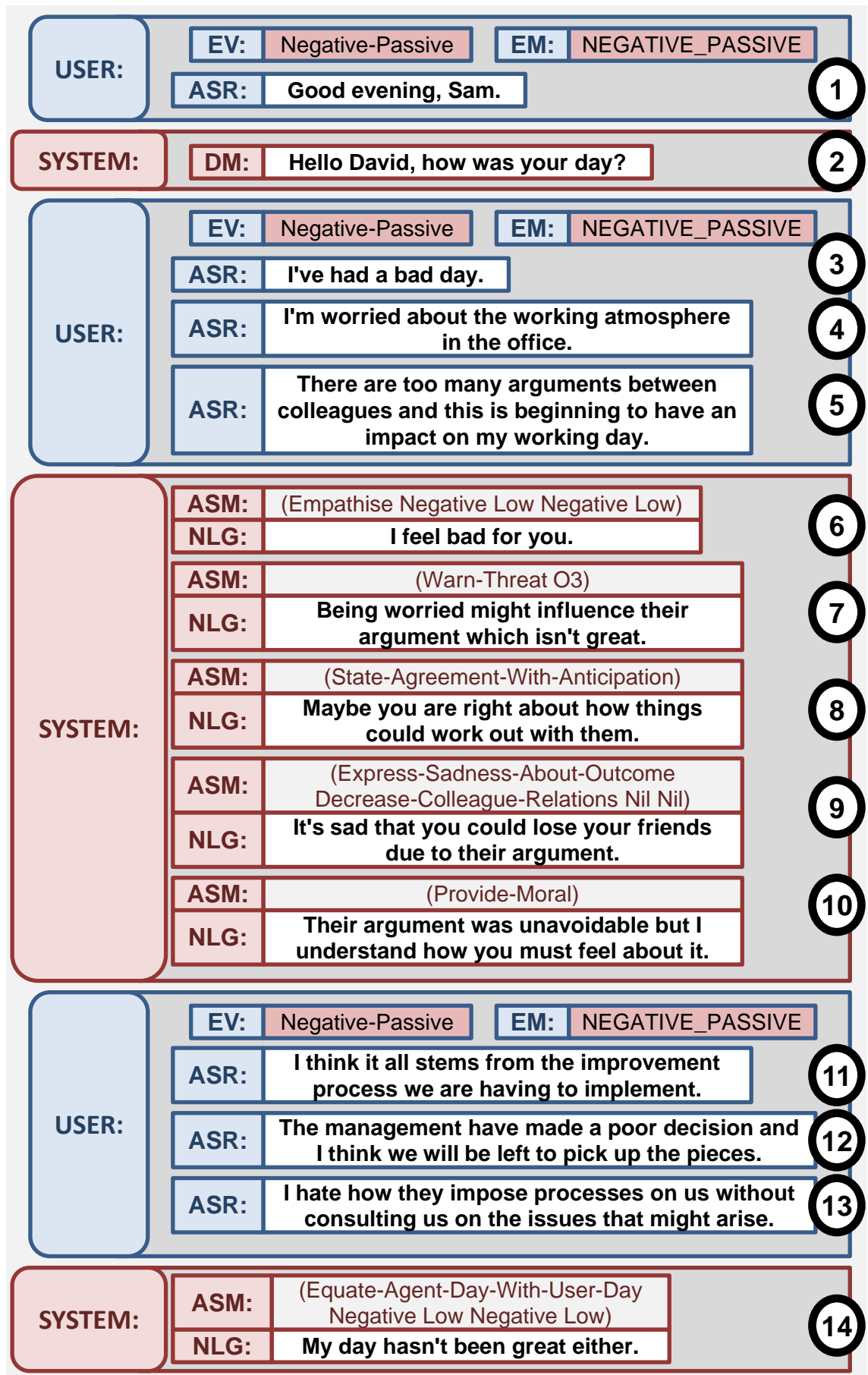
#### **7.4.2. An extended dialogue mainly employing Sympathetic strategies**

Example 7.2 presents a dialogue typical of the form aimed for with the HWYD Companion. The bulk of the dialogue consists of alternating sequences of multiple, consecutive, moderate length utterances from both the user and Companion.<sup>16</sup> This clearly departs from the template of task-oriented dialogue and moves into the realm of conversation. The average utterance length further expands on those seen in Example 7.1 (with over 13 words per utterance from the user and 10 words per utterance from the system). Indeed one user utterance is 39 words long indicating the Companion is capable of handling user utterances far longer than the previous task-oriented dialogue examples (Chapter 4).

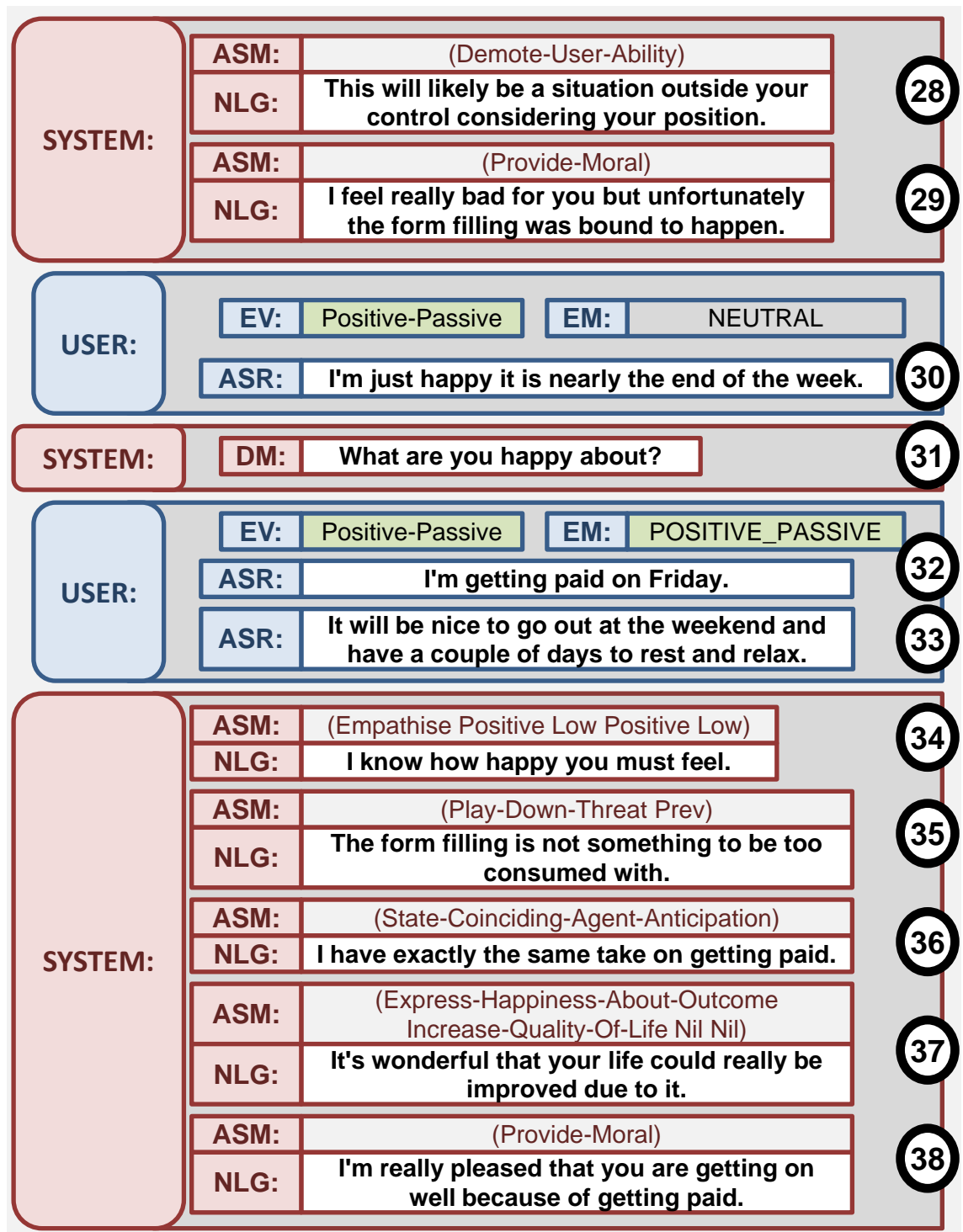
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<sup>15</sup> The use of text-based input prevents the use of the Acoustic Turn Taking module and the Interruption Manager with such functionality as the ‘Short Loop’ generation and handling of interruptions being thereby excluded. However, this does not significantly impact the generation of dialogue extracts when considering the role of the ASM.

<sup>16</sup> Alternatively, as the distinction of individual utterances is defined merely by the ASR, this dialogue may also be viewed as a formal turn-based dialogue consisting of very long utterances. In either case, the important point is that this dialogue no longer resembles the formal turn-based dialogues of short to moderate length utterances of task-oriented dialogue and small talk.



SYSTEM:	ASM:	(Commend-Response-To-Specific-Situation)	15
	NLG:	Well I have to admire the way you are handling the bad management decision.	
	ASM:	(Result-Is-Not-Fair Event-Actualised Management-Decision-Prove-Detrimental Negative-Aftermath Nil)	16
	NLG:	It's really unfair that it could harm your current situation.	
	ASM:	(Demote-User-Ability)	17
	NLG:	With your circumstances you may have a problem you cannot solve.	
	ASM:	(Warn-Threat Prev)	18
	NLG:	The dispute might influence it which isn't great.	
	ASM:	(Provide-Moral)	19
	NLG:	I know this can be annoying but there was not much you could do about the bad management decision.	
USER:	EV:	Negative-Passive	20
	EM:	NEGATIVE_PASSIVE	
	ASR:	Yeah, and don't get me started on all the paperwork.	21
	ASR:	I can't believe there is so much.	
	ASR:	We barely get a chance to do anything else most of the time.	22
	ASR:	I really hate the attitude where they seem to think it is okay to make us write out five different forms to raise a purchase request just so they can tick a couple of boxes for their strategic goals.	23
SYSTEM:	ASM:	(Empathise Negative Low Negative Low)	24
	NLG:	I feel your pain.	
	ASM:	(Outcome-Is-Not-Fair Waste-Time Nil Nil)	25
	NLG:	It's hardly fair that you could needlessly waste time.	
	ASM:	(State-Agreement-Regarding-Situation)	26
	NLG:	You're right it is a bad situation I agree.	
	ASM:	(Warn-Threat Prev)	27
	NLG:	The bad management decision could create more form filling which isn't great.	



**Example 7.2:** An extended dialogue mainly employing Sympathetic strategies.

The conversation is broken into two main sections differentiated by affect: the majority of the dialogue maintains a **Negative-Passive** affect as the user deals with the events of a bad day before switching to a **Positive-Passive** affect at the end as the user looks forward to the weekend. The **Negative-Passive** affect is built up from a combination of the **Negative-Passive** results from EmoVoice and the negative sentiment obtained from the SA's analysis of the ASR output. Similarly the change to **Positive-Passive** affect is brought about by both the change in the user's tone (detected as **Positive-Passive** by EmoVoice) and a switch in the displayed sentiment; the earlier section employs negative words such as "bad" (line 3) and "worried" (line 4) while the final section sees usage of words with a positive sentiment such as "happy" (line 30) and "nice" (line 33). Due to the accumulation of negative emotional instances the transition towards a positive affect is not immediate with the EM first returning **Neutral** (line 30) before the balance of positive affect swings the result towards **Positive-Passive** (line 32, 33).

The conversation is effectively divided into a series of exchanges defined by the user's account of a given set of events and the Companion's corresponding narrative response. There are a range of events and influences recognised by the Companion across the conversation. The portion of the dialogue with negative affect naturally focuses on events with a negative outcome for the user. Within the first exchange the NLU module is able to recognise a **bad day** event (line 3), that the user is experiencing an emotion of **worry** (line 4) and that there are **arguments** occurring (line 5). Within the next exchange, the user provides details of an improvement process. While the NLU module does not recognise the improvement process itself as an event, it is able to recognise a **bad management decision** event (line 12). In the next exchange the discussion of paperwork (line 20) and the need to complete various forms (line 23) is recognised by the NLU module as the **form filling** event. With the switch towards discussing the weekend, the user describes events with a positive outlook. This includes **getting paid** (line 32) and having some days to rest and relax (line 33) which is recognised as a **working** event of low-intensity.

Within the first section the combination of an overall negative affect and the selection of deterioration events lead to the Companion employing a Sympathetic strategy for each narrative response. For each of the events, the **arguments**, **bad management decision** and **form filling**, the outcome has already been realised and thus there is no

hope of a protection process being enacted. As there is no need for persuasion, with the Companion and user sharing the same outlook on the situations discussed, the role of the narrative response is to affirm the user's position in each case. There are two main parts to this: that the Companion is able to show empathy with the user's situation and that the Companion is further able to reinforce the user's behaviour as appropriate for the situation, despite the negative outcome.

Naturally the first point of empathising with the user is through the opening response to the user's emotional reaction and the Companion has several options for how to accomplish this. The Companion may choose to do this directly by targeting the user's affect, such as with the **Empathise** operator (lines 6 and 24). Here the Companion attempts to directly relate to the negative affect by presenting it as a shared reaction, such as with "I feel your pain" (line 24). Alternately, the Companion may choose to identify more with the user's position than with the emotion, such as with the **Equate-Agent-Day-With-User-Day** operator (line 14), and attempt to create a link in that way.

However, this is not the whole extent to the process of empathising as there are further steps which build upon this initial reaction. In particular, the Companion will seek to acknowledge the negative aspects by way of establishing a shared appreciation of events. This may be to acknowledge the bad situation itself (line 26), to acknowledge the negative impact felt by some additional influences such as being worried (line 7) or to refer to the negative impact of the previously discussed dispute (line 18). The impact of events upon the user may be further developed through the **Comment-on-Outcome** operators. For example, the Companion is able to empathise with the user by expressing sadness at the way an argument may impact relationships (line 9), by stating how unfair the results of a bad management decision are (line 16) and by stating how unfair it is that form filling will waste the user's time (line 25).

While within a Sympathetic strategy the Companion is not actively attempting to persuade the user to adopt a different outlook, there is nevertheless the goal of positively influencing the user's attitude. Thus it is not sufficient to merely empathise with the user's negative situation but rather the Companion must attempt to make the user feel better about the negative situation itself. The approach employed is of reinforcing the appropriateness of the user's behaviour and attempting to alleviate any guilt the user may feel for the situation's outcome. The first aspect of this is seen in explicitly commending how the user handles the situation (line 15) and approving of

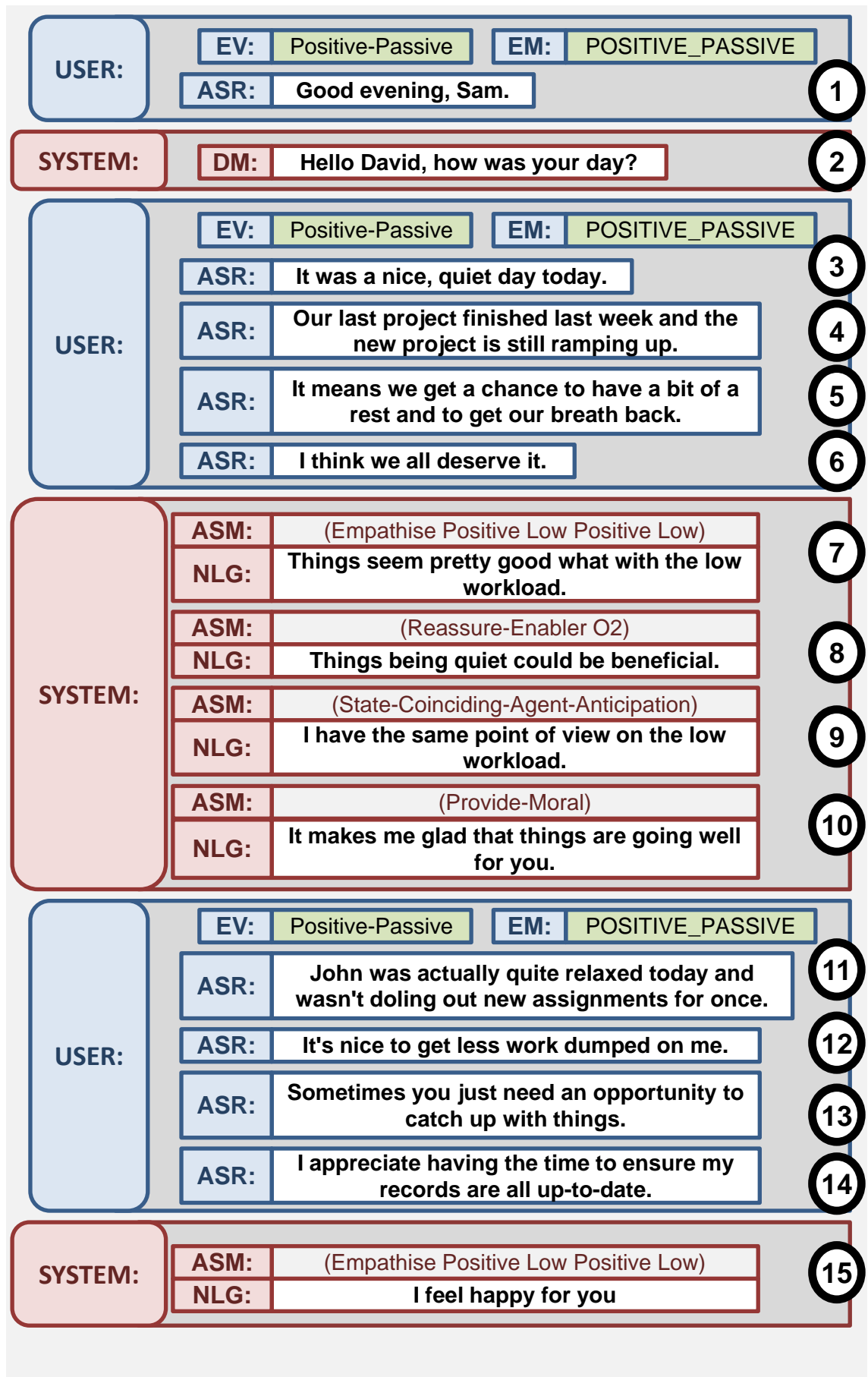
their anticipation of events (line 8). Further, to remove responsibility the Companion uses the **Demote-User-Ability** operator (lines 17 and 28) to highlight that the events are outwith the user's control. Finally, the conclusion of each narrative response, and the **Provide-Moral** operator employed (lines 10, 19, 29), attempts to both underscore the acknowledgement of the negative situation and exempt the user from responsibility.

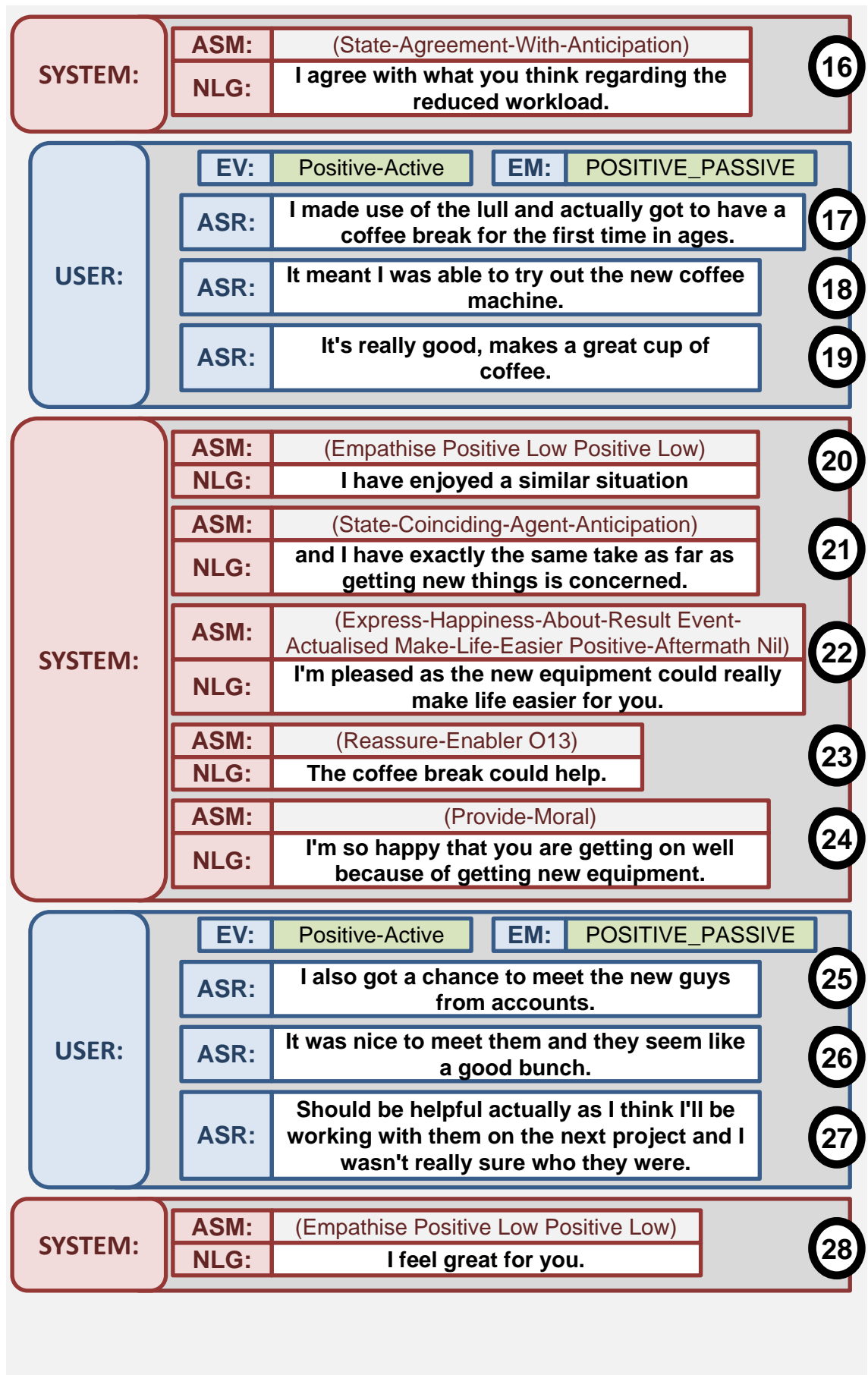
In the final section of this example the affect moves from negative to positive and this brings a corresponding switch from a Sympathetic strategy to a Congratulatory strategy and the narrative response naturally switches from a negative focus to a positive focus. As again there is no difference in outlook, there is no attempt at persuasion and the approach in both these strategies is equivalent (but with the change towards a positive affect). So we again see the same two steps of empathising with the user and reinforcing the appropriateness of their behaviour. The Companion attempts to empathise with the user's reaction (line 34) and downplay the previous problem of form filling (line 35) while being happy at the positive impact upon the user, namely their quality of life being improved (line 37). Stating that their anticipations coincide (line 36) serves to both present a shared anticipation, and thus to empathise, while implicitly reinforcing the appropriateness of the user's behaviour.

#### **7.4.3. An extended dialogue employing Congratulatory strategies**

Example 7.3 provides another conversation of a similar length and form to Example 7.2 but where the user's affect is exclusively positive. Thus the narrative responses employ a Congratulatory strategy throughout.







SYSTEM:	ASM:	(Express-Likelihood-Of-Result Event-Actualised Contacts-Helpful-In-Future Positive-Aftermath Nil)	29
	NLG:	<b>It's likely the new contacts you make could prove useful in the future.</b>	
	ASM:	(Reassure-Helper O21)	30
	NLG:	<b>I'm sure the new guys from accounts will help you out.</b>	
	ASM:	(Reassure-Enabler Prev)	31
	NLG:	<b>Also getting new equipment could be beneficial.</b>	
	ASM:	(State-Agreement-With-Anticipation)	32
	NLG:	<b>You are likely right about how things could turn out with meeting new people.</b>	
	ASM:	(Provide-Moral)	33
	NLG:	<b>I'm really pleased that everything has worked out so well.</b>	

**Example 7.3:** *An extended dialogue employing Congratulatory strategies.*

The user discusses a range of work situations within Example 7.3 from which the NLU module is able to identify several events: that activity within the office has been quiet (line 3), as opposed to busy, that the user has only needed to be working at low intensity (line 5) and that the user's workload has decreased (line 12). While being similar, each NLU module event embodies a distinct nuance and thus is also modelled independently by the ASM. Further, the user goes on to discuss a coffee break (line 17) where they tried a new coffee machine (treated as a new acquisition event, line 18) and was able to meet new people (line 25).

As discussed in Chapter 5, events have different rankings based on their significance and, even as main events, do not provide the same range of options for the ASM. For example, the bad day event previously discussed in Example 7.1 is very general and so does not provide any outcomes for a Comment-on-Outcome operator. Similarly the working and workload events in Example 7.3 do not provide outcomes to be discussed. Thus the density of information provided by the user accounts for the difference in size between narrative responses; little information results in a short narrative response, such as with lines 15 and 16, while a more significant event along with multiple event influences results in a longer narrative utterance, such as with lines 28 to 33.

As mentioned for the final section of Example 7.2, the approach of the Congratulatory strategy is effectively a mirror of the Sympathetic strategy. Therefore the focus on empathising with a negative situation becomes a focus on empathising with the user's positive situation. Thus, in addition to the **Empathise** operator (line 7, 15, 20 and 28 of Example 3), the Companion emphasises shared ground such as shared anticipations (line 9, 16, 21 and 32) and acknowledges positive influences (line 8, 23, 30 and 31) such as the coffee break and the new guys from accounts. This is further reinforced by discussing the impact of outcomes such as the coffee machine making the user's life easier (line 22) and new contacts proving useful in the future (line 29).

There is also the aspect of reinforcing the appropriateness of the user's behaviour, as with discussion of the anticipations (line 9, 16, 21 and 32), but this is not as pronounced as with the Sympathetic strategy. The impetus behind this response in the Sympathetic strategy is to prevent the user from blaming themselves for their negative situation. With a positive situation there is obviously no negative attribution and the appropriateness of the user's behaviour can be clearly assumed. As a result there is no equivalent to the **Demote-User-Ability** operator employed with a Sympathetic strategy; to use the **Promote-User-Ability** operator is unnecessary and may be inappropriate for the situation being discussed. For example, telling the user they have the ability to cope with a negative situation may be seen as reassuring but would be odd when referring to using a new coffee machine. This shift away from the appropriateness of the user's response in favour of empathising with the positive situation is followed in the presentation of the **Provide-Moral** operator. The summary presented with this operator is equivalent to the **Empathise** operator employed for a positive situation but this time with an explicit reference to the main event being discussed (eg. line 24).

#### **7.4.4. An extended dialogue mainly employing Reassuring strategies**

Having dealt with those situations where the user's affect is the motivating aspect, we now consider those situations where the appropriateness of the user's anticipation is the main determinant for the affective strategy. Example 7.4 provides a conversation where the user shows a consistently negative affect and takes a negative outlook towards the events discussed. The Companion meanwhile takes a positive outlook on most events leading to a correspondingly predominant usage of Reassuring strategies to positively influence the user.

USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	1
	ASR:	Good evening, Sam.			
SYSTEM:	DM:	Hello David, how was your day?			2
USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	3
	ASR:	It's been a rather poor day.			4
	ASR:	We were told that management will introduce cutbacks next month.			5
	ASR:	This will mean my department's budget is slashed by 30% and will have to make efficiency savings.			6
	ASR:	I'm not sure how we will be able to cope.			
SYSTEM:	ASM:	(Empathise Negative Low Negative Low)			7
	NLG:	I have been through similar problems.			8
	ASM:	(Commend-Response-To-General-Situation Negative)			9
	NLG:	The situation is certainly as you thought and I think you are behaving appropriately			10
	ASM:	(State-Disagreement-With-Anticipation)			11
	NLG:	but I'm not convinced you are right about how they will affect you.			12
	ASM:	(Express-Likelihood-Of-Result Event-Actualised Limited-Scale-Of-Cutbacks Positive-Aftermath Nil)			13
	NLG:	Try not to focus on the cutbacks I'm sure they are only on a small scale.			14
	ASM:	(Provide-Moral)			
	NLG:	It seems clear to me that sometimes things work out okay in the end.			
USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	12
	ASR:	I'm worried that my boss may make some redundancies in the department.			13
	ASR:	I doubt we can keep going without losing any staff.			14
	ASR:	I'm not sure what this will mean for me as I'm the latest addition to the team and I'm sure they'll want to keep the most experienced members.			

SYSTEM:	ASM:	(Empathise Negative Low Negative Low)	15
	NLG:	Things seem pretty bad considering the redundancies	
	ASM:	(Commend-Response-To-General-Situation Negative)	16
	NLG:	You are right about the situation and I'm sure you will be able to handle things.	
	ASM:	(State-Contrasting-Agent-Anticipation)	17
	NLG:	Though I see things differently with the redundancies.	
	ASM:	(Express-Likelihood-Of-Result Pre-Actualisation Find-Additional-Funding Event-Prevented Nil)	18
	NLG:	I'm sure if additional funding is secured you will be able to avoid them.	
	ASM:	(Promote-User-Ability)	19
	NLG:	Someone with your skills shouldn't have an issue coping with them.	
USER:	EV:	Negative-Passive	22
	EM:	NEGATIVE_PASSIVE	
	ASR:	I just feel so unhappy about the situation.	23
	DM:	What will you do now?	
	EV:	Negative-Passive	24
	EM:	NEGATIVE_PASSIVE	
	ASR:	I guess I will need to look for a new job.	25
	ASR:	I have some days holiday to take so can make a start on it then.	
	ASR:	There is just so much that needs to be done.	26
	ASR:	I'll have to make sure my CV is up-to-date and that I have a copy of my current job profile.	
USER:	ASR:	I don't imagine it will be easy to find something else in the current financial climate either.	27
	ASR:		28

SYSTEM:	ASM:	(Empathise Negative Low Negative Low)	29
	NLG:	I feel your pain.	
	ASM:	(Commend-Response-To-Specific-Situation)	30
	NLG:	I have to applaud the way you are dealing with the job hunt	
	ASM:	(State-Contrasting-Agent-Anticipation)	31
	NLG:	but I look at things another way with it.	
	ASM:	(Result-Is-Fair Pre-Actualisation Keep-Existing-Job Event-Prevented Nil)	32
	NLG:	I wouldn't worry too much about job hunting as it's only fair that you won't lose the one you have	
	ASM:	(Promote-User-Ability)	33
	NLG:	and with your skills you shouldn't have an issue coping with the situation.	
	ASM:	(Reassure-Enabler O16)	34
	NLG:	Also the holiday could be beneficial	
USER:	ASM:	(Play-Down-Threat O14)	35
	NLG:	but being depressed isn't a problem worth spending too long on.	
	ASM:	(Provide-Moral)	36
SYSTEM:	NLG:	It is worth remembering that sometimes the worst doesn't happen.	
	EV:	Negative-Passive	37
	EM:	NEGATIVE_PASSIVE	
	ASR:	The problem is it will be hard to find the time to look.	38
SYSTEM:	ASR:	I had a very busy day and I imagine it will only get worse.	
	ASR:	There is so much to do in the office right now that everyone will be rushed off their feet for the next couple of weeks.	39
	ASR:		
SYSTEM:	ASM:	(Equate-Agent-Day-With-User-Day Negative Low Negative Low)	40
	NLG:	You're having a day like me.	
SYSTEM:	ASM:	(Demote-User-Ability)	41
	NLG:	Being busy will likely be a problem you cannot solve considering your position.	

SYSTEM:	ASM:	(Warn-Threat Prev)	42
	NLG:	The job hunt could influence it which isn't great.	
	ASM:	(Outcome-Is-Not-Fair Increase-Workstress Nil Nil)	43
	NLG:	It's hardly fair that you'll become more stressed.	
	ASM:	(State-Agreement-With-Anticipation)	44
	NLG:	I reckon you are correct about how things could turn out with it.	
	ASM:	(Provide-Moral)	45
	NLG:	Being busy was bound to happen but I understand how annoying it can be.	

**Example 7.4:** *An extended dialogue mainly employing Reassuring strategies.*

The form and average utterance length of Example 7.4 is similar to those of Examples 7.2 and 7.3 but this example is longer with 45 utterances. As with Example 7.2, the user shows a **Negative-Passive** affect and this persists throughout the conversation. Example 7.4 may be considered an archetypal example of conversation with the HWYD Companion; the user adopts a negative view of their situation and the Companion responds, for three of the four narrative responses presented, with a Reassuring strategy, attempting to persuade the user that a more positive outcome is possible.

The user maintains a continuing thread throughout the discussion with one potential problem feeding into the next and the Companion presents a narrative response to each problem. The NLU module identifies the **cutbacks** event (line 4), that the user is **worried** about potential **redundancies** (line 12), that the user will use their holiday (line 25) in order to start a **job hunt** (line 24) and that the search for a new job will be complicated by **activity** at the office being **busy** (line 38).

The approach for the Reassuring strategy begins in a similar fashion to that of a Sympathetic strategy. The Companion attempts to empathise with the user's reaction to their situation, such as with the **Empathise** operator (lines 7, 15 and 29), and to reinforce that the user's emotional reaction is appropriate (lines 8, 16 and 30). However, once this common ground has been established the contrasting anticipation of the Companion is introduced (lines 9, 17 and 31). The goal is not to rebuke the user for holding a different anticipation but to gently suggest that there is another possible



outcome. The Companion attempts to leverage the common ground from the shared reaction to make the user more amenable to an alternative.

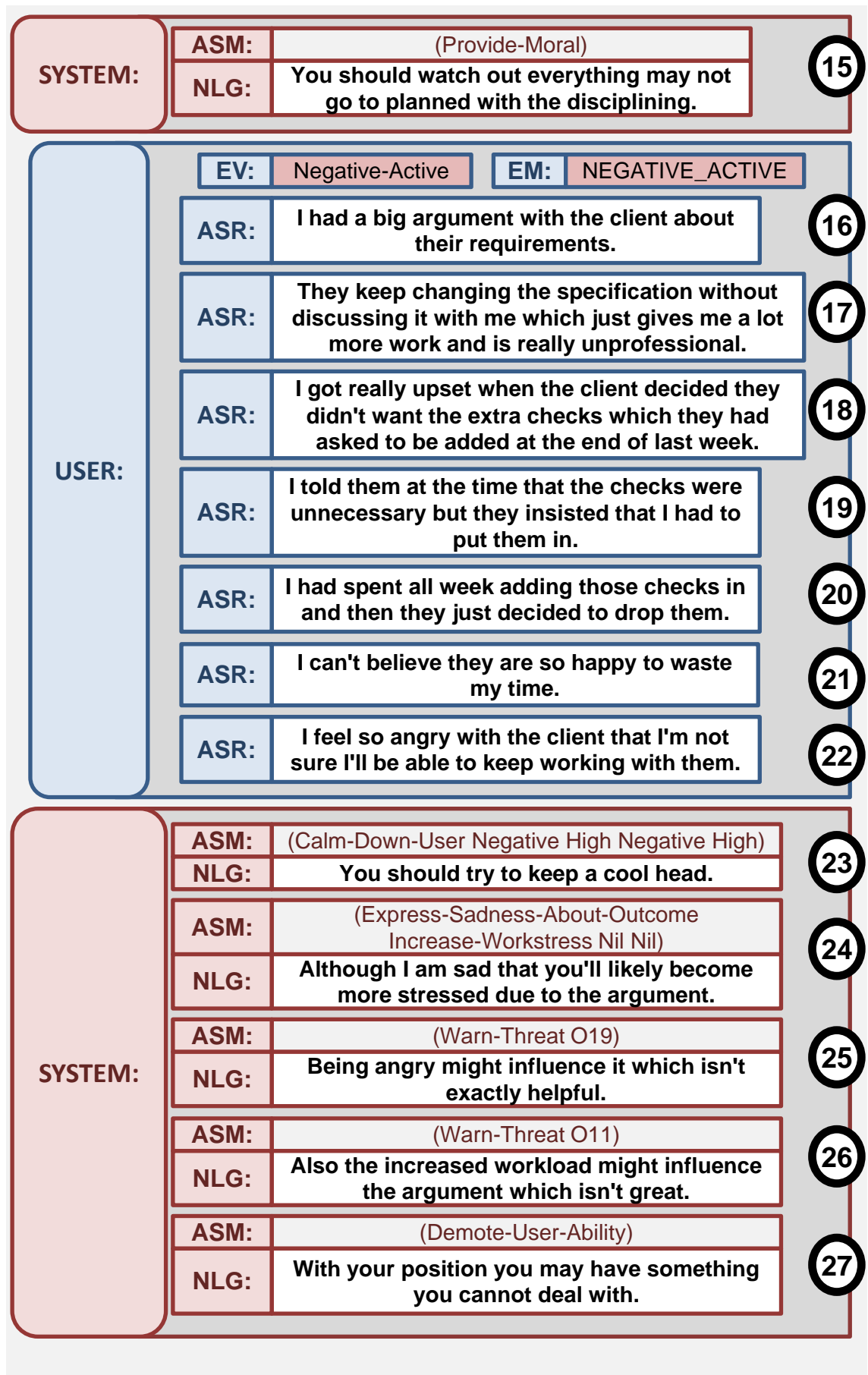
Once the suggestion has been made that there is an alternative, the Companion follows this up with details of another potential outcome such as some future event which acts to prevent the negative outcome from occurring. For example, the Companion suggests that it is likely that the user will be able to avoid the redundancies if the company finds additional funding (line 18). Similarly, the Companion suggests it would be only fair that the user could avoid the job hunt through keeping their existing job (line 32). The Companion also suggests that while the negative outcome may occur, the resulting aftermath will not be as negative as anticipated for the user. For example, the suggestion that it is likely that even if the cutbacks are introduced, that they will have a limited impact (line 10).

The rest of the narrative response is devoted to reinforcing this positive message. The Companion may discuss additional influences: downplaying the threat of emotions such as being worried or depressed (lines 20, 35) or highlighting the benefits of a holiday (line 34). The Companion also encourages the user directly in their ability to effect this positive change through the **Promote-User-Ability** operator (lines 19 and 33). The final utterance of the narrative response, provided by the **Provide-Moral** operator (lines 11, 21 and 36), also focuses on reinforcing the positive message; the user is directly urged to consider a more positive outlook.

#### **7.4.5. An extended dialogue mainly employing Cautionary strategies**

The counterpart to the influence of the Reassuring strategy is that of a Cautionary strategy which is shown in Example 7.5. This example presents a conversation with the user where once again the overall affect shown is negative. However, in this case the user shows an often unduly positive anticipation and this is then challenged by the Companion.

USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	1
	ASR:	Good evening, Samantha.			
SYSTEM:	DM:	Hello David, how was your day?			2
USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	3
	ASR:	It's been a pretty rubbish day.			
SYSTEM:	DM:	Please tell me.			4
USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	5
	ASR:	I'm just feeling pretty depressed.			
SYSTEM:	DM:	What are you sad about?			6
USER:	EV:	Negative-Passive	EM:	NEGATIVE_PASSIVE	7
	ASR:	My boss threatened me with a disciplinary action but I think it will be okay.			
	ASR:	He thought my treatment of a client was inappropriate though I think it is clear the client is the one in the wrong.			8
SYSTEM:	ASM:	(Empathise Negative Low Negative Low)			9
	NLG:	Things seem pretty bad considering the disciplining.			
	ASM:	(Express-Worry-About-Outcome Decrease-Reputation Nil Nil)			10
	NLG:	I'm nervous that it may have an impact on your reputation.			
	ASM:	(State-Agreement-Regarding-Situation)			11
	NLG:	It is a bad situation I agree			
	ASM:	(Query-Anticipation-Of-Outcome)			12
	NLG:	but how do you think it will affect you?			
	ASM:	(Question-User-Ability)			13
	NLG:	Are you sure you have the skills necessary to handle issues from it?			
	ASM:	(Warn-Threat O3)			14
	NLG:	Being depressed could influence the disciplining which isn't exactly helpful.			



SYSTEM:	ASM:	(State-Coinciding-Agent-Anticipation)	28
	NLG:	I have the same point of view as far as the dispute is concerned	
	ASM:	(Commend-Response-To-Specific-Situation)	29
	NLG:	and I have to admire the way you are handling it.	
	ASM:	(Provide-Moral)	30
	NLG:	I am sorry you are in such a bad situation but unfortunately the dispute was bound to happen.	
USER:	EV:	Negative-Passive	31
	EM:	NEGATIVE_PASSIVE	
	ASR:	I may fail the next milestone as a result of all this though I reckon I'll manage.	32
	ASR:	My boss is pretty bothered about it but I don't think it is my responsibility.	
SYSTEM:	ASR:	If the client can't agree a proper specification then how am I supposed to complete things on schedule.	33
	ASM:	(Empathise Negative Low Negative Low)	34
	NLG:	I feel bad for you.	
	ASM:	(Question-User-Ability)	35
	NLG:	Are you convinced you have the abilities necessary to handle problems from the failed milestone?	
	ASM:	(Warn-Threat Prev)	36
	NLG:	The dispute could influence it which isn't exactly helpful	
	ASM:	(Express-Worry-About-Result Event-Actualised Demotion Negative-Aftermath Nil)	37
	NLG:	and I'm worried that failure could result in a demotion.	
	ASM:	(Advise-On-Anticipation-Of-Outcome)	38
	NLG:	I wouldn't count on it to play out as you expect.	
	ASM:	(Provide-Moral)	39
	NLG:	You need to be cautious not everything goes according to plan.	

**Example 7.5:** *An extended dialogue mainly employing Cautionary strategies.*

The form of Example 7.5 differs slightly from the previous examples which have presented a fairly balanced set of sub-dialogues. Here the user appears initially reticent, offering minimal responses (lines 3 and 5) and the DM provides three prompts for information (lines 2, 4 and 6) before the user then provides sufficient event information (lines 7 and 8) for a narrative response (lines 9 to 15). The user then responds with a lengthy, angry (**Negative-Active** affect) monologue which spans seven consecutive utterances (lines 16 to 22). These utterances are themselves quite lengthy with an average of over 18 words per utterance, pushing the overall count to over 15 words per utterance for all user utterances in this example. This serves to demonstrate the Companion's ability to handle the extremes either side of the typical form; both minimal responses requiring consistent prompting and extended sequences of user input made up of lengthy utterances.

From the initial exchanges with the DM the NLU module derives that the user has had a **bad day** (line 3) and they are feeling **depressed** (line 5) as a result of being threatened with **disciplining** (line 7) by their boss. The NLU module is then able to identify that the user engaged in an **argument** with a client (line 16), which resulted in an **increased workload** (line 17) and the user being **angry** at the client (line 22). Further, the user may **fail a milestone** as a result (line 31).

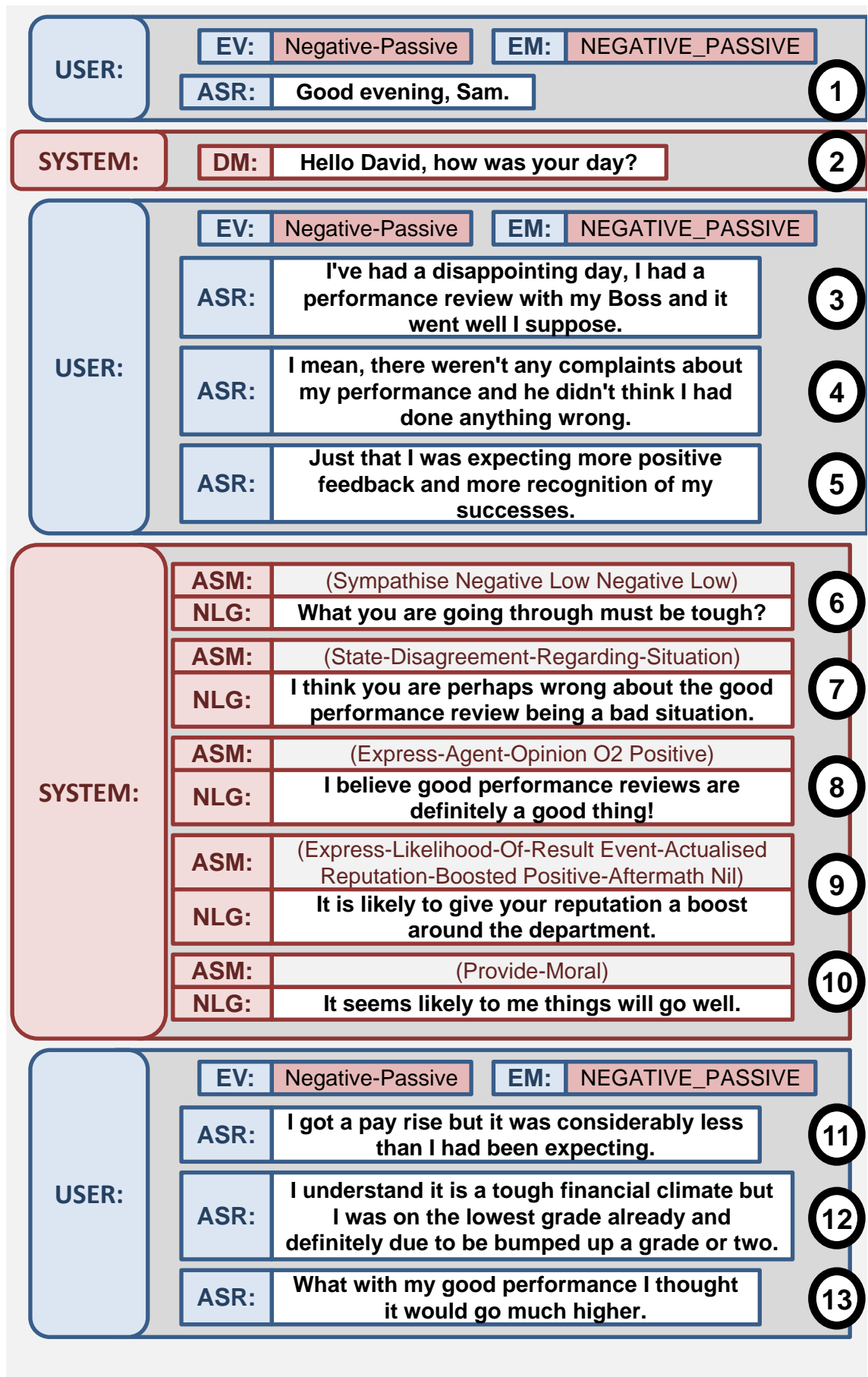
The outworking of the Cautionary strategies proceeds in a similar manner to the Reassuring strategy. The Companion establishes common ground with the user through the use of the **Empathise** operator (line 9 and 34) and by affirming the appropriateness of the user's reaction (line 11). The user's anticipation is then gently challenged (lines 12 and 38) to introduce an alternative outcome. This is supplemented in the Cautionary strategy by the use of the **Question-User-Ability** operator (lines 13 and 35). As with challenging the anticipated outcome, the role of the operator is not to assert that the user lacks the ability necessary but rather to challenge the confidence in their own ability.

The alternative anticipation is once again reinforced by presenting an alternate outcome, though this time a negative outcome. For example, the Companion expresses worry that the disciplining may negatively impact the user's reputation (line 10) or, similarly, that the failed milestone may result in demotion for the user (line 37). This is reinforced by highlighting the negative aspects, such as warning the user about being depressed and about the argument (lines 14 and 36). Finally, the **Provide-Moral** operator (lines 15 and 39) closes by once again challenging the notion of a successful outcome.

Not all the narrative responses provided in Example 7.5 employ a Cautionary strategy; the user's lengthy monologue (lines 16 to 22) sees the Companion respond with a lengthy narrative response (lines 23 to 30) which employs a Sympathetic strategy. Similarly, Example 7.4 with predominantly Reassuring strategies ends with a narrative response guided by a Sympathetic strategy and, as discussed, Example 7.2 transitions from Sympathetic strategies to a Congratulatory strategy. This highlights that there is no issue with a diversity in the affective strategy employed nor even the affect shown within a conversation so long as the Companion remains consistent within the context of a given narrative response. For example, the Sympathetic strategy in Example 7.5 is embedded between the two Cautionary strategies. While the tone of the Sympathetic strategy is incompatible with the tone of the other two, they do not conflict since the context is different for each. The sympathetic tone of the second narrative response will not detract from the challenge of the first narrative response, nor vice versa, as they remain self-contained.

#### **7.4.6. An extended dialogue employing Encouraging strategies**

We have now covered strategies for those situations where the Companion and user agree and those where they differ in anticipation. The remaining affective strategies cover those situations where the Companion and user differ in terms of the emotional reaction shown towards the user's situation. Example 7.6 presents a conversation where the user discusses their day's events with a negative affect for what the Companion considers should feature a positive affect. The Companion therefore employs Encouraging strategies to try to persuade the user to adopt a positive outlook on the events. The form of Example 7.6 returns to the familiar pattern of Example 7.3 though is shorter at 20 utterances long. However, the average utterance length for user utterances continues at the 15 words per utterance length of Example 7.5. This once again shows the Companion's ability to handle longer user utterances. The overall affect of the conversation remains **Negative-Passive** throughout as the user expresses disappointment with the day's events. The NLU module is able to recognise that the user had a **bad day** (line 3) after having a **good performance review** (line 3) and that the user then received a **pay rise** (line 11). The Companion naturally attributes positive affect to the **good performance review** and **pay rise** events and so an Encouraging strategy is employed in both cases to attempt to influence the user's perception of the events.



SYSTEM:	ASM:	(Sympathise Negative Low Negative Low)	14
	NLG:	<b>You must feel terrible</b>	
	ASM:	(Express-Agent-Reaction O7 Positive Low)	15
	NLG:	<b>but listen the pay rise sounds fantastic!</b>	
	ASM:	(Outcome-Is-Fair Increase-Quality-Of-Life Nil Nil)	16
	NLG:	<b>It's only right that your quality of life could be improved by it.</b>	
	ASM:	(Advise-On-Response-To-Specific-Situation)	17
	NLG:	<b>How about trying to look at the pay rise from another perspective?</b>	
	ASM:	(Promote-User-Ability)	18
	NLG:	<b>With your skills you shouldn't have an issue handling it</b>	
	ASM:	(Reassure-Enabler Prev)	19
	NLG:	<b>and you know the good performance review could be beneficial.</b>	
	ASM:	(Provide-Moral)	20
	NLG:	<b>I'm sure everything will work out.</b>	

**Example 7.6:** *An extended dialogue employing Encouraging strategies.*

The difference in emotional reaction to the events entails a change in approach for the Companion's persuasion. While the previous strategies have sought to leverage the shared emotional reaction to build on the common ground with the user, this is no longer possible. However, the Companion must still start by acknowledging the user's reaction. The **Sympathise** operator (lines 6 and 14) differs from the previously used **Empathise** operator by acknowledging the user's reaction without communicating that this is shared by the Companion. This acknowledgement is necessary to establish the basic common ground required for defining the context of the conversation but this basic common ground is insufficient for further use in influencing the user. As a result, the Companion attempts to establish a new emotional baseline for the reaction by providing emotional expressions itself which support the target reaction. For example, the Companion provides the opinion that a good performance review is a positive situation for the user (line 8) and also provides a positive affective reaction to the pay rise (line 15).

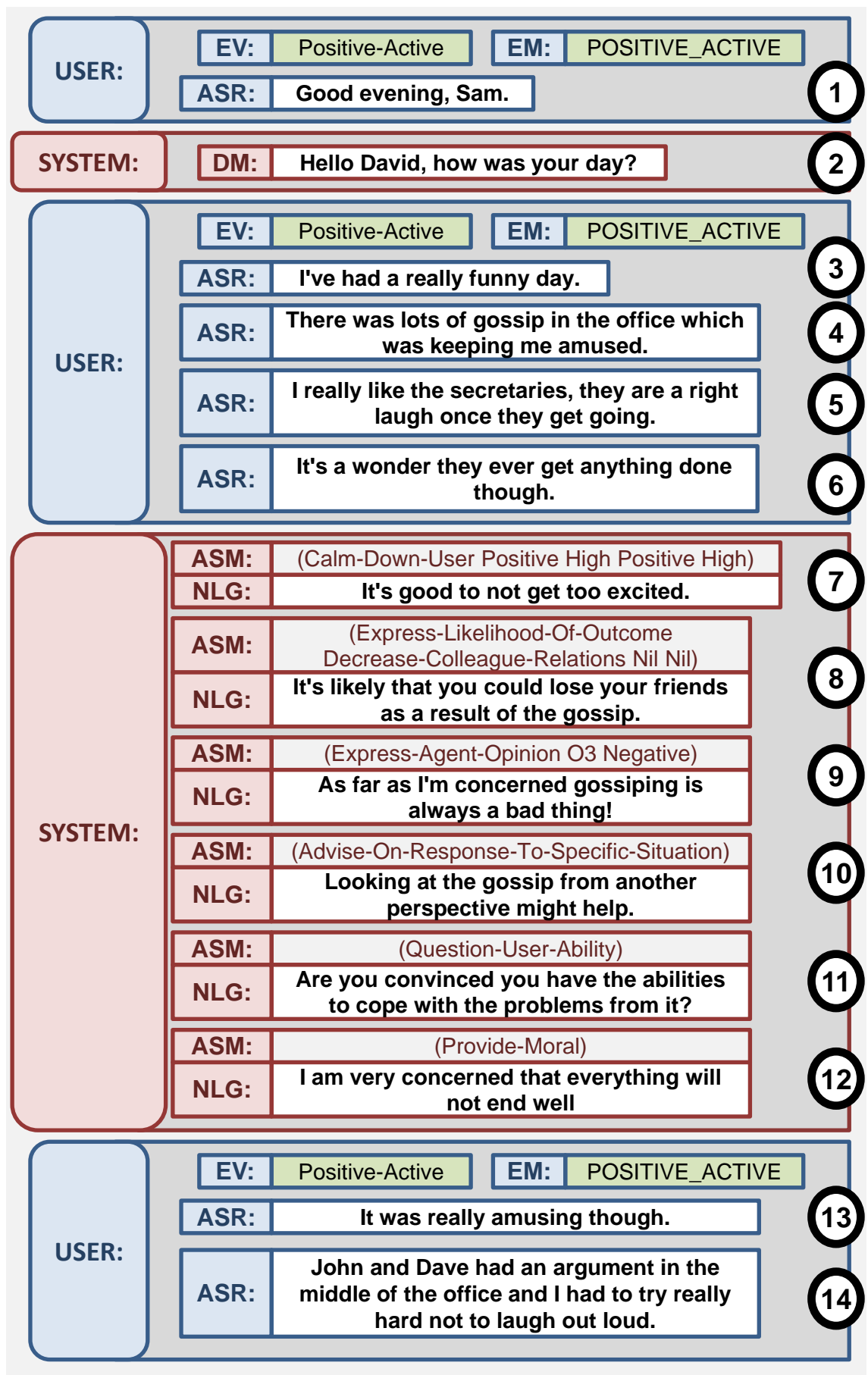


With a new affective baseline established the Companion must next define the terms of disagreement (the differing emotional reactions) as well as the reason for the user to alter their attitude. The Companion may present the disagreement outright (line 7) or, similar to a Cautionary strategy, by challenging the user on their response (line 17). Once the alternative emotional reaction has been presented, the Companion follows this up with details in support of its argument. As with the Reassuring strategy, this reinforcement consists of presenting a positive focus through positive influences (line 19), through promoting the user's ability (line 17) and through specific positive outcomes. For example, the Companion highlights the likelihood that the good performance review may lead to an improved reputation for the user (line 9) and that the pay rise would improve the user's quality of life (line 16). The **Provide-Moral** operator (lines 10 and 20) likewise seeks to reinforce the positive affect.

#### **7.4.7. An extended dialogue employing Warning strategies**

The final strategy, the Warning strategy, presents elements of both the Encouraging and Cautionary strategies; it attempts to correct an inappropriately positive emotional reaction through a focus on the negative aspects of the situation. Example 7.7 presents a conversation where the user shows an inappropriately positive reaction to negative events and the Companion employs Warning strategies to attempt to alter the user's attitude towards a more appropriate negative affect. Throughout Example 7.7 the user responds with **Positive-Active** affect towards the events of their day. The NLU module is able to recognise that there was **gossip** in the office (line 4) and that the user **likes** the **secretaries** (line 5). Further, that **John** and **Dave** had an **argument** (line 13) and that the user **hates John** (line 15). The Companion considers **gossip** and an **argument** to be deterioration events and so employs the Warning strategies to correct the user.

As with the Encouraging strategy, the Companion cannot use the user's emotional reaction as a baseline and so must establish a new emotional baseline. The initial Companion responses in Example 7.7 tackle the user's high emotional arousal with the **Calm-Down-User** operator (lines 7 and 19) but the **Sympathise** operator would also be possible to acknowledge the user's reaction. The Companion then asserts the opinion that **gossip** is a bad thing (line 9) and that it **hates arguments** (line 21) to provide the appropriate emotional reaction. Further, the reaction to the situation is disputed both by suggesting a change in perspective (line 10) and questioning whether the user's reaction is correct (line 20).



USER:	ASR:	I hate John, he has such an inflated image of himself.	15
	ASR:	We used to say that he always took so long to enter a room because he has to let his ego go in first since they both wouldn't fit through the door.	16
	ASR:	And Dave really took him down a notch because John was just talking rubbish in front of everyone and Dave just tore his argument apart.	17
	ASR:	John didn't know what to say in response so he just walked out.	18
SYSTEM:	ASM:	(Calm-Down-User Positive High Positive High)	19
	NLG:	You should try to not get ahead of yourself.	
	ASM:	(Query-Response-To-General-Situation Positive)	20
	NLG:	Perhaps you should take a look at the situation from another angle?	
	ASM:	(Express-Agent-Emotion Hate O10 True)	21
	NLG:	Personally I absolutely hate arguments!	
	ASM:	(Question-User-Ability)	22
	NLG:	Are you sure you have the skills necessary to handle the effects arising from their argument?	
	ASM:	(Warn-Threat Prev)	23
	NLG:	The gossip might influence the argument which isn't great.	
	ASM:	(Warn-Antagonist O9)	24
	NLG:	Also be careful as John could make trouble for you.	
	ASM:	(Play-Down-Likelihood-Of-Outcome Conserve-Colleague-Relations Person O9)	25
	NLG:	It's doubtful that your relationship with John won't be affected.	
	ASM:	(Provide-Moral)	26
	NLG:	It worries me that things may not work out with their argument.	

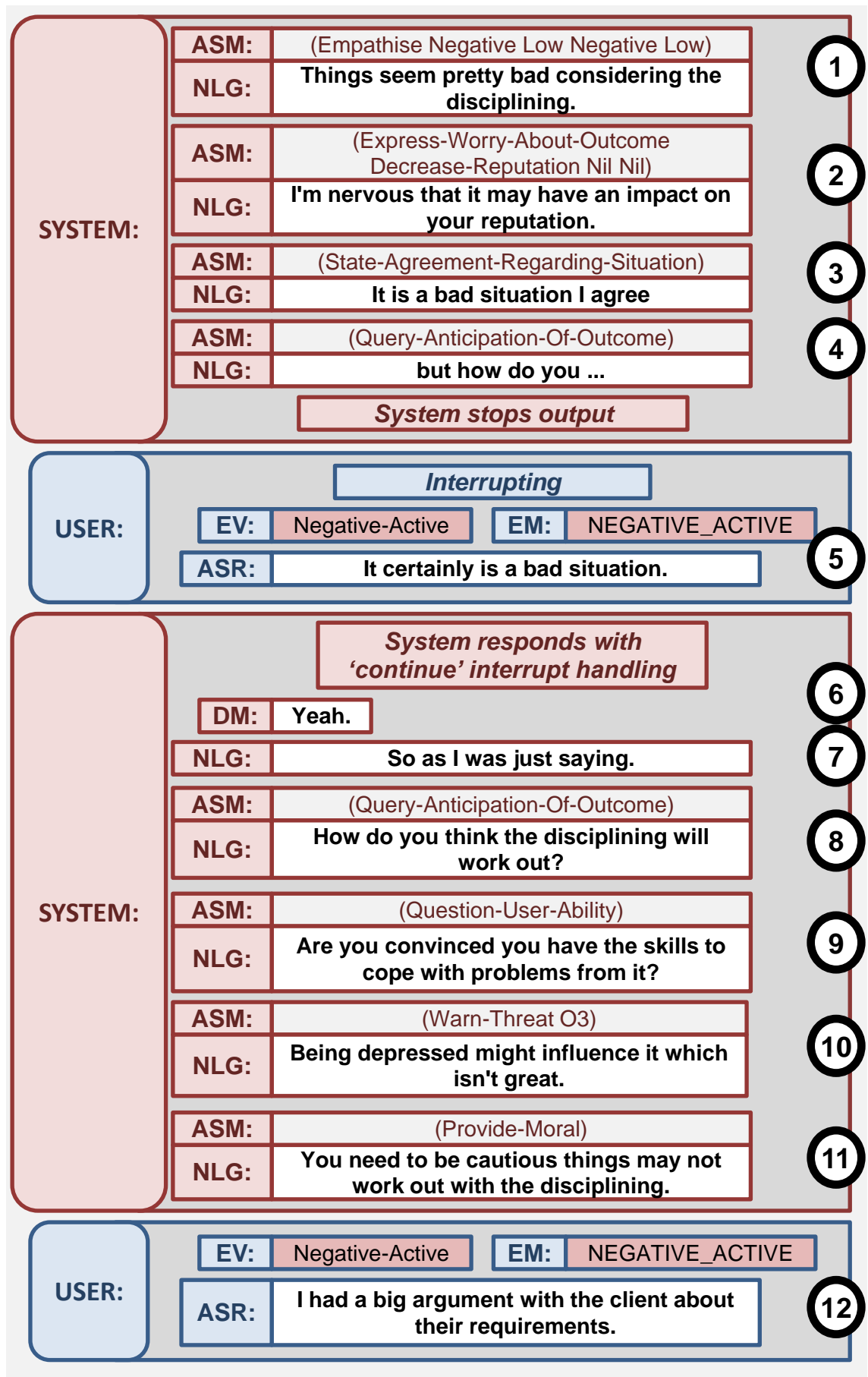
**Example 7.7:** *An extended dialogue employing Warning strategies.*

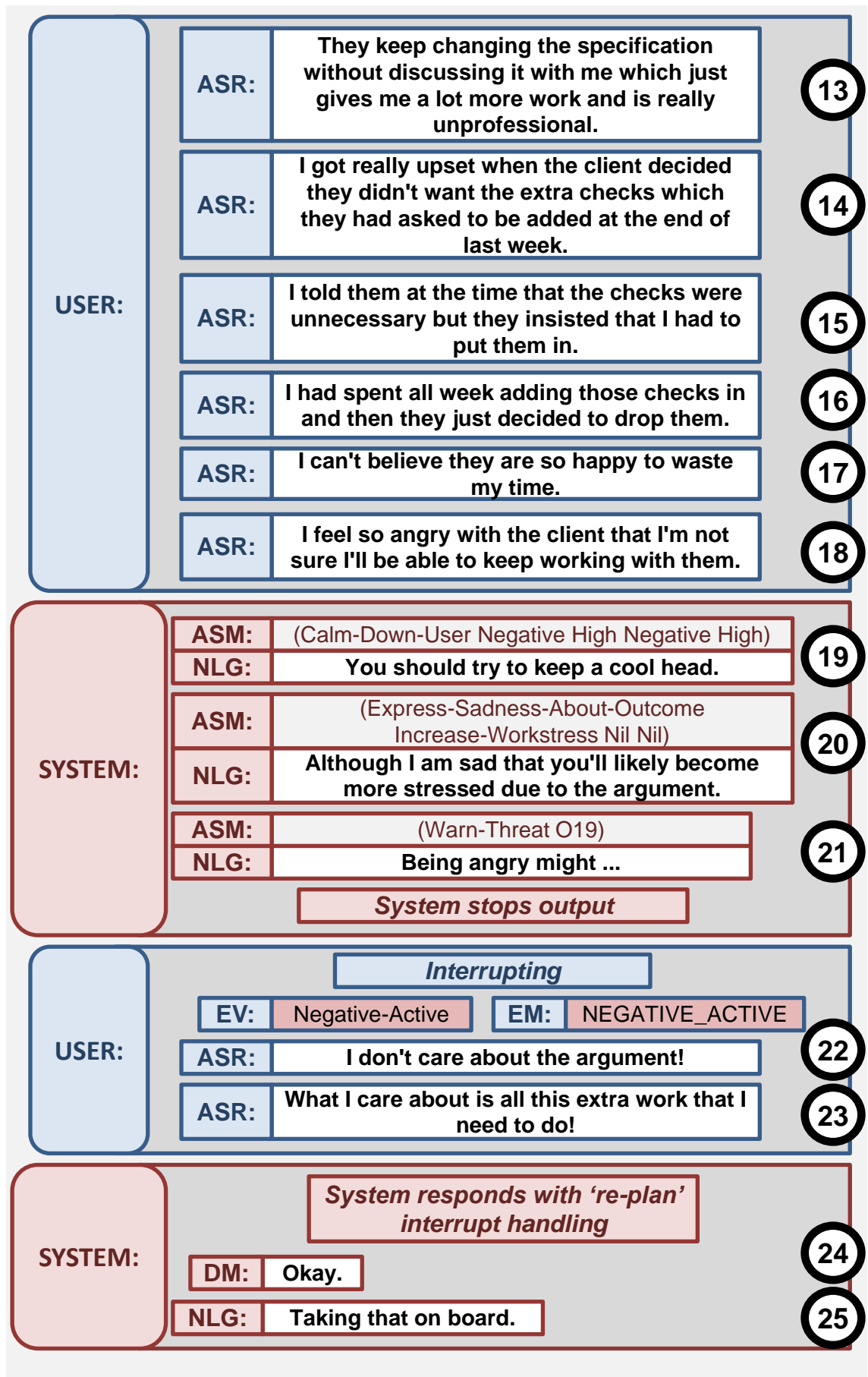
As with the Cautionary strategy, the Companion then completes the narrative response by focusing on the negative aspects. The Companion once again prompts the user to reconsider their position with the **Question-User-Ability** operator (lines 11 and 22). The negative influence of gossip is also highlighted (line 23) along with a warning to be careful in handling John (line 24). The **Provide-Moral** operator (lines 12 and 26) similarly focuses on the potential for a negative outcome. This is explicitly stated by the outcome operators with the Companion mentioning the likelihood of gossip negatively impacting relationships (line 8) and further that the response to the argument is likely to have a negative effect upon the user's relationship with John (line 26).

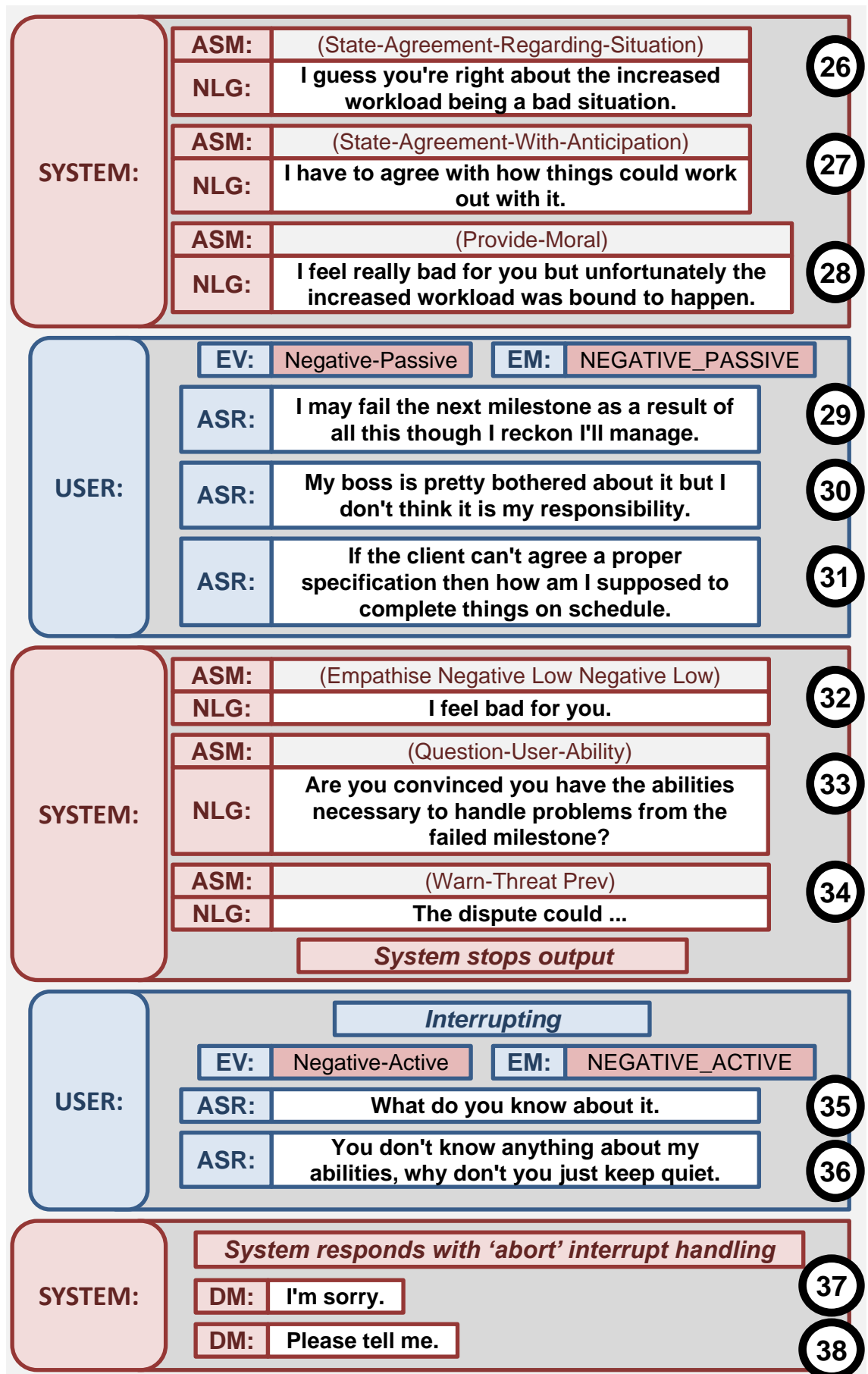
#### **7.4.8. An extended dialogue showing interruption handling**

One final aspect of conversation not yet covered is the role of interruptions. The handling of interruptions is not a focus for the ASM yet the generation of narrative responses for the Companion increases the likelihood of the user interrupting a Companion utterance (due to the increased time required to deliver a response). Further, while control of the interruption handling is shared between the Interruption Manager and the Dialogue Manager, the ASM is still required to support certain functionality in order to enable interruption handling within the Companion as a whole.

Example 7.8 presents a version of Example 7.5 modified to illustrate the differing forms of interruption supported by the Companion. The first narrative response is interrupted by the user (line 5, Example 7.8) in what is understood as agreement with the Companion. This prompts 'continue' interrupt handling with the Companion continuing from the point of interruption (line 6 to 11). Subsequently the user interrupts again (lines 22 and 23) with what is understood as a correction to the main event being discussed. The Companion responds with 're-plan' interrupt handling (lines 24 to 28) which leads the ASM to generate a new narrative response using the amended information. The final interruption (lines 35 and 36) has the user rejecting the Companion's response entirely which leads the Companion to employ the 'abort' interrupt handling to discontinue the dialogue (lines 37 and 38) until the user provides further information.







**Example 7.8:** *An extended dialogue showing interruption handling. This example, adapted from Example 7.5, shows the different forms of interruption handled by the system and their corresponding effects on the dialogue. The opening lines of the conversation are omitted, with line 1 here corresponding to line 9 in Example 7.5.*

The focus here is on the role played by the ASM in supporting these interruptions. This role varies depending on the particular form of interruption identified by the DM. The lesser involvement is with an ‘abort’ interruption (lines 34 to 38). Here the ASM merely generates a plan for the narrative utterance as normal. The delivery of this response is subsequently halted with the user’s interruption and the DM discontinues the conversation with no further action required of the ASM until it is invoked for a future narrative response.

The ASM is more important in the realisation of a ‘continue’ interrupt (lines 4 to 11). Upon the interruption of a narrative response, the ECA component records the particular utterance where the interruption took place. Once the DM determines a ‘continue’ interrupt is appropriate, the ASM is invoked to perform the ‘continue’ interrupt and is passed the number of the utterance where the interruption took place. The ASM then assembles a version of the previous plan from the point of interruption and passes this directly to the NLG module (as with a normal plan). The NLG module then realises this plan into utterances as normal and passes this to the ECA for output to the user. While the underlying plan remains the same, the regeneration of the surface forms (the NLG module having been re-invoked) means the output will be slightly different from the previously interrupted narrative response (compare lines 12 to 15 of Example 5 with lines 8 to 11 of Example 7.8).

The ‘re-plan’ interrupt (lines 21 to 28, Example 7.8) provides the most work for the ASM as this entails some change to the information used to generate a narrative response. The DM is responsible for handling what information is changed, removed and preserved from the original narrative response and invoking the ASM with this information. As the ASM is largely state independent this essentially means that the ASM is just required to generate a new narrative response from the information provided as with any other new narrative response. However, as the user has just interrupted a previous narrative response, it may not be appropriate to deliver a full narrative response directly to the user once more. Thus the ASM uses the number of the utterance where the interruption took place to determine how far through the previous



narrative response the user was and adjusts the size of the new plan accordingly. For example, interrupting the first utterance in a plan will see a full new plan being generated while interrupting the last utterance will see the ASM focus on the **Address-Outcome** decomposition for the new plan. In Example 7.8, the user interrupts the third utterance of eight and so the regenerated plan skips the **Spontaneous-Reaction** and **Comment-Process** stages and provides only **Respond-to-User-Reaction**, **Address-Outcome**<sup>17</sup> and **Conclusion** stages.

## **7.5. Meeting the challenges of conversational dialogue**

Having examined several examples of extended dialogues with the HWYD Companion and a full range of user situations, some more general conclusions can now be drawn about the ability of the HWYD Companion to meet the challenges set by conversational dialogue. First is that the Companion has shown the ability to handle longer user utterances than typical of previous dialogue systems, with user utterances being around twice the length of those within task-oriented dialogue systems such as TRAINS and HMIHY. Further, this is presented within the context of user and Companion providing multiple consecutive utterances leading to dialogues of a form quite distinct from the strict turn-based structure of such task-oriented dialogue systems.

The dialogues also demonstrate the importance of the affective component to the Companion. Two different approaches (within two different modules) are used in the collection of affective information with this then integrated to provide a consistent emotional state for the user. The user's emotional state is then pivotal in the production of a narrative response which engages with the situation described by the user, particularly with regards to the selection of the affective strategy employed by the Companion.

The examples further illustrate the range of challenges for dialogue management within these conversations. Throughout the DM has catered for the mixed-initiative, user-led dialogue including the extremes of such dialogues: from prompting for event information when this is not forthcoming to dealing with sections of lengthy, consecutive user utterances. The first example, Example 7.1, also demonstrates the Companion's approach to providing a timely response with the IM providing a 'short

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<sup>17</sup> Although the **Address-Outcome** decomposition does not actually result in an operator because the main event in the re-planned narrative response is too minor to warrant it.

loop' response while the approach to interruption handling is presented in the final example, Example 7.8.

While the ASM has contributed in varying ways to each of these objectives, the provision of a narrative response to the user has been its focus. The examples have shown that the ASM has been successful in the generation of plans of multi-utterance responses for a range of situations and across a range of affective states. However, the provision of a narrative response requires more than a list of utterances. The utterances themselves must contribute to the dialogue beyond just the overall form of the narrative response by providing content which adds meaningfully to the conversation.

## **7.6. The HWYD Companion versus the ChatterBot approach**

This once again draws a comparison between a ChatterBot approach and the HWYD Companion's approach to conversation. While the difference between the Companion's dialogues and those of task-oriented dialogue systems can clearly be seen this may not be so obvious when considering ChatterBot dialogue. Despite the difference in form, with the ChatterBot dialogue staying much closer to the pattern of task-oriented dialogue, there are also noticeable similarities. As discussed in Chapter 4, both ChatterBots and the HWYD Companion employ an approach similar to that of person-centred therapy which depends on creating rapport with the user. Yet, as also mentioned previously, the technique used by the Companion to generate these responses involves a much deeper level of processing compared to the ChatterBot approach. This can be seen in the nature of the different responses provided both by a ChatterBot, such as in Example 4.6, and by the HWYD Companion in the examples in this chapter.

The first difference lies in the use of dialogue management to maintain a conversation over several dialogue turns. A ChatterBot will typically provide no dialogue management and responses are predicated on the content of the previous dialogue turn. As in Example 4.6, this can lead to very disjointed conversations where the ChatterBot will repeatedly initiate tangential topic shifts. Meanwhile the Companion's Dialogue Manager maintains a full dialogue history and is able to track topics over multiple dialogue turns. This is demonstrated by the DM asking follow-up questions about a topic before eventually invoking the ASM with a more complete set of information. The ASM too is able to take into account the dialogue history, both using the accumulated information from the DM and storing the main event information from the previous

narrative response to use as an additional event influence for the next narrative response.

Another difference is in the ability of the HWYD Companion to handle the affective aspects of dialogue. ChatterBots have no ability to discern the affective state of the user. This ties in with the objective of small talk to not provide an affective impact. Yet the Companion attempts a deeper level of dialogue where the affective information is an important component. Thus the Companion not only gathers affective information from the user but this information is pivotal to the generation of the resulting response. This further feeds into the difference between how the Companion and ChatterBot attempt to understand the information provided by the user. The ChatterBot approach is reliant on syntactic pattern matching rather than any semantic reasoning about the user's information. This does not attempt to understand what the user means but merely looks for matches based on what was actually said. In comparison the Companion builds a specific understanding of the user's situation through reconciling the user's description of events with the ASM's knowledge base. The ASM's appraisal process provides a deep semantic analysis of the user's situation covering the impact of a given event on the user and the appropriateness of their response.

The final difference is in how the information gained from assessing the user's utterances is employed to provide a response. The ChatterBot merely selects from the matching rules to provide a template response. At the more advanced level this may substitute in some information from the pattern match to instantiate the resulting template (such as "I know Neil Young" in Example 4.6). Meanwhile with the ASM the information from the appraisal process is used both to select the affective strategy that guides the Companion's response and to determine the content for that response. The information provided by the user tailors the Companion's response to precisely fit the user's situation; at the lowest level the operators provide a particular communicative function that is customised based on the user's topics and affective state while at a higher level these operators are woven into a narrative response to enact a particular form of persuasion. Thus both the information provided by the user and a detailed analysis of that information determine the HWYD Companion's response.

An awareness of these differences therefore serves to precisely distinguish between the responses provided by ChatterBot and Companion. They also illustrate that the HWYD Companion is able to provide a meaningful contribution to the conversation. Even when

completely successful and able to sustain the ‘ELIZA effect’, a ChatterBot maintains a conversation with no substance. It will progress the conversation but does not attempt to contribute anything meaningful that will impact the user. As a result the best it can provide is superficial small talk. In contrast the narrative response provided by the HWYD Companion attempts to engage with the user at an emotional level and actively persuade the user. The result is that a successful response from the Companion will be able to positively influence the user’s attitude and thus provide a meaningful impact upon the user.

Thus the ASM’s generation of narrative responses can be seen to be successful in terms of the generation of the multi-utterance responses themselves and also in the way in which it supports the goals of conversation. It enables the HWYD Companion to both present a dialogue in the form of conversation and provide a meaningful contribution to the content of the conversation.

## **7.7. Conclusion and references to additional information**

This chapter has presented results from the fully working HWYD Companion demonstrator including details of the public demonstrations performed and the user testing undertaken. Further it has presented extended dialogues produced by the working system which demonstrate conversation with the Companion across a range of situations.

The examples have illustrated the full range of affective strategies employed by the Affective Strategy Module to respond to the user: Sympathetic and Congratulatory strategies which are employed where the Companion and user share a common outlook on the user’s situation and which seek to show empathy; Reassuring and Cautionary strategies which are employed where the Companion and user have differing anticipations and which seek to influence the user to adopt the Companion’s outlook; Encouraging and Warning strategies which are employed when the user shows an inappropriate emotional reaction and which seek to persuade the user to adopt an appropriate emotional reaction to their situation. Additionally the examples illustrate the form and structure of such dialogues and show the interruption handling provided by the Companion.

The chapter concluded with a discussion of how the Companion is able to meet the challenges of conversational dialogue. This included discussion of how the ASM is able to provide a meaningful contribution to the conversation and how this is different from a ChatterBot approach. Additional results covering other aspects of the complete HWYD Companion have been discussed in other publications.

Within (Cavazza et al, 2010) was presented a preliminary system validation. This employed the Sentiment Analysis parser used within the HWYD Companion to check the appropriateness of the narrative responses generated by the system. The first metric employed provided a ‘correctness’ score of 81% while the second, more demanding, metric provided a ‘correctness’ score of 71%.

Within (Smith et al, 2011) was presented an evaluation of the HWYD Companion which included dialogue metrics, user metrics and appropriateness analysis. This evaluation consisted of extended sessions with 12 participants where each participant carried out initial training of the system, a series of 7 testing scenarios and concluded with a questionnaire and interview. The scenarios were constructed to test a range of situations in which the user would interact with the Companion (see Section 7.3 of this Thesis for details). The dialogue metrics presented an average WER of 0.37 and CER of 0.33 showing problems with ASR performance. However user metrics found that, despite the poor ASR results, the participants were able to use the system and found the Companion to be polite, friendly and to show a sense of personality. The evaluation also carried out appropriateness analysis which identified those areas where the Companion performed best and those areas requiring improvement. This helped suggest areas of further development including new conversational mechanisms and the need for additional visual feedback.

Finally, within (Crook et al, 2012) was presented an in-depth discussion of the HWYD Companion’s ability to generate context-sensitive responses to user barge-in interruptions.

## **8. Conclusion**

### **8.1. Overview**

I have presented a novel approach for Embodied Conversational Agents that unifies persuasive and affective strategies as part of enabling human-computer conversation. The focus of this work has been on the ‘How Was Your Day’ Companion and, in particular, the Affective Strategy Module. This chapter will consider the contribution made by both the HWYD Companion and the ASM. Further, it will examine some possible directions for future work.

### **8.2. Contribution of the HWYD Companion**

The HWYD Companion is a fully implemented proof of concept demonstrator for conversational dialogue. This is significant as there are a limited number of fully implemented dialogue systems with which to test new dialogue phenomena. In providing a system focused on the genre of conversation, including the affective aspects, the HWYD Companion distinguishes itself from the bulk of dialogue systems focused on task-oriented dialogue. It is a fairly large dialogue system (covering around 100 discreet events) and has provided several notable contributions such as narrative persuasion (Cavazza et al, 2010) and multiple interaction strategies in support of open conversation (Smith et al, 2010) including the handling of user interruptions (Crook et al, 2012). Further, it has been publicly demonstrated at a range of venues, such as AAMAS 2010 and the ICT 2010 Conference, and shown to support extended dialogues; there is no defined limit for the length of dialogues and the demonstration dialogues have typically lasted over 10 minutes.

#### **8.2.1. My contribution to the HYWD Companion**

My work in this Thesis has contributed specialised functionality to the overall HWYD Companion. It is necessary for this work to be embedded within a larger system due to the great complexity of the overall system and the particular scope of my own work. In being part of such a large integrated system I have been able to benefit from colleague’s expertise in areas such as emotional speech recognition, sentiment analysis, natural language understanding and dialogue management. Thus I have been able to maintain my focus on augmenting dialogue management within the context of a dialogue system

which is capable of state of the art affective dialogue processing. This would not have been possible had I been responsible for the development of a complete end-to-end system.

### **8.2.2. Problems of an integrated system**

Yet in being part of a large integrated system there is also a reliance on other modules providing the necessary information. A particular problem has been the reliable capture of information by the ASR and EmoVoice. While capable of a very accurate representation of a user's utterances, both modules are also prone to suddenly deteriorating quality. Further these modules have proven heavily dependent on the performance of individual users. Practise with the system has enabled greatly improved performance and thus those project members demonstrating the system have received more reliable results. However, for new users testing the system the results have remained poor.

As discussed in Chapter 7, the Companion is able to show robustness in coping with intermittent problems and isolating their effect on the greater part of the conversation. Unfortunately sustained problems cannot be so easily countered and this further provides a cascading effect on subsequent modules. As shown in Example 7.1 this can lead to a lack of information with which to instantiate a narrative response or to the Companion providing an inappropriate narrative response because of incorrect initial data (such as the use of a Warning strategy at the end of Example 7.1).

Due to these problems and the overall complexity of the installation and execution of the integrated system it has also proven difficult to gather a suitable range of user testing within the timescales of the COMPANIONS project. The evaluation discussed in (Smith et al, 2011) completed testing of 12 users and these tests suffered from significant ASR and EmoVoice recognition error rates.

This difficulty in testing the overall system has therefore made it difficult to receive results on the persuasive performance and success of the narrative responses employed by the Companion. However, the preliminary system validation, presented in (Cavazza et al, 2010), has shown success in the intended display of agent affect with a 'correctness' score of 81%. Nevertheless, it would be desirable to receive more feedback on the success both of individual operators and overall strategies. Such

information would be useful for further work in developing the strategies and refining the existing operators.

### **8.2.3. Contributions to conversational dialogue**

Despite these problems the HWYD Companion can be seen to have made a firm contribution towards achieving conversational dialogue. It supports dialogue that is not constrained to a task but allows the user to share personal topics within free conversation. It also allows for a greater level of expression from the user compared to task-oriented dialogues by supporting flexibility in the turn structure and longer utterances containing affective elements. Further it is capable of complex, multi-utterance responses that engage with the user's affective state.

### **8.2.4. Contributions of the ASM**

The contribution of the ASM plays an important part in this. It is fully integrated with the rest of the Companion and is crucial to the provision of conversational dialogue. It supports the processing of affective information which is integral to the eventual response provided by the Companion. It also supports the processing of user interruptions with special functionality for handling 'continue' and 're-plan' interruptions. Finally, of course, the ASM is instrumental in the preparation of narrative responses. The preparation of these narrative responses provide a notable contribution in themselves: encapsulating influence within a narrative response rather than through argumentation. This approach is able to integrate the affective aspects of conversation and apply these in the use of an attitude-centred persuasive system.

## **8.3. Areas of further development**

There are two areas of further development that can be highlighted for the HWYD Companion. Both of these focus on the Companion's relationship with the user. The first involves maintaining the Companion's relationship with the user across repeated interactions. The second involves increasing the scope for this relationship by incorporating conversational dialogue within additional task-oriented dialogues.



### **8.3.1. Persistence of user data**

Preserving the relationship with the Companion across sessions demands more than just maintaining a history of the interaction but further requires the Companion to make use of that history in subsequent conversations. Essentially this would allow the Companion to grow and develop its relationship with the user by getting to know the user and their preferences better and applying this to future interactions.

For example, in the HWYD domain the Companion would benefit from adapting the event knowledge to better match the individual user's outlook. If the user does not like having to meet with new people then the entry in the knowledge base may be revised from an improvement process to a deterioration process for that user. Further, additional information from the user's dialogue may be stored in the knowledge base for use in subsequent sessions. This may include further details about the user's work (the user works in the Finance team), about additional actors (the user's boss is called John), the user's relationship with others (the user dislikes Dave) and upcoming events (the user is on holiday next week). All this information would provide more data for use in compiling a response, require fewer assumptions about the user's situation and therefore provide a more appropriate response for the user. It also enables the user to develop a 'shorthand' with the Companion such that the Companion can, over time, recognise complex dynamics in certain situations (such as the implications of a particular colleagues promotion) with less input from the user. This further develops the relationship between the user and the Companion.

The HWYD Companion has already been developed with this approach in mind with the provision of a separate module acting as a knowledge base for dialogue management. This allows the HWYD Companion to maintain a long-term user profile for storing information gathered during conversation with the user. Further this knowledge base is built such that this previously stored knowledge can be integrated with new information from user conversations and thus used when inferring links during the appraisal process. Thus the HWYD Companion just requires a mechanism for deciding upon which information should be added to the user profile and how to manage changes to the information stored there.

### **8.3.2. Integrating conversational dialogue with task-oriented dialogue**

The second area of further development considers the integration of task-oriented dialogues with conversational dialogue. The HWYD Companion currently offers open conversation where the user may freely discuss the events of their day without any overarching structure for the dialogue. It is desirable that some of this freedom may be incorporated into an otherwise task-oriented dialogue, thus providing a more natural interaction for the user, while maintaining the overall purpose of the dialogue. This would allow for deviations from the progression of the main task in order to deal with social, relational or affective dialogue while preserving the overall context of the discussion.

For example, some further applications for a Companion were considered on the COMPANIONS project which would support a more task-oriented structure but also allow room for domain-oriented conversation. One such is a Cooking Companion which could provide advice on selecting a meal and then provide recipe instructions to guide the user in its preparation. Conversational dialogue may be provided alongside this such as discussion of cooking related topics that do not directly contribute to accomplishing the cooking task but which build the relationship with the Companion. Further, the Cooking Companion may be integrated with other domains such as the HWYD Companion. Thus the user may be able to talk about a stressful day at work and received reassurance from the Companion while waiting for the potatoes to cook.

Supporting this integration would require both specific domain knowledge for the given tasks and the ability to correctly switch between topics of discussion. The preparation of a task domain is relatively straightforward in that it would essentially be equivalent to the task domain for a standard task-oriented system. However, the domain and knowledge base would benefit from a wider remit than is necessary for accomplishing the task so this can be applied to a wider conversation. The dialogue manager would then need to keep track of the various topics under discussion as well as progress made on the main task. This may require an aspect of prioritisation such that the task is not abandoned by sidetracking the user into a tangential conversation. There may also be a temporal aspect to the topic management, such as with the need to interrupt a conversation to pursue the next stage in the recipe (such as removing food from the oven) before then continuing the interrupted conversation.

### **8.3.3. Role of the ASM in this further development**

The ASM plays a role in both these areas of new development. Indeed, the creation of a persistent user profile would centre on both the ASM and DM. For the integration of task-oriented dialogue with conversational dialogue the exact involvement of the ASM with the task-oriented element would have to be determined. However, at the very least the ASM would remain responsible for narrative responses within the conversational part of the dialogue. The ASM could easily be integrated with other Companion applications given the appropriate domain event definitions for the ASM's knowledge base. The appraisal process would require information on how such events would impact the user and the generation would require additional outcomes for each event. However, the overall generation framework could remain in place with the necessary data to drive it. Further, as with the discussion of the Cooking domain previously, this may not even require a new domain since the DM may invoke the HWYD domain as an aside from whatever task-oriented discussion was being carried out.

### **8.3.4. Applying narrative persuasion to Interactive Storytelling applications**

Outside of dialogue, the ASM's approach of narrative persuasion could also be applied to other applications. This would be for the purpose of generating complex sets of communication acts which could encapsulate a specific form of influence. For example, this may be applied to applications such as Interactive Storytelling. This would allow the dynamic generation of lengthy persuasive monologues for certain characters. The categorisation of the appraisal process would naturally fit here given its inspiration from Brémond (1973). However, in addition to the development of a suitable knowledge base for the domain used, this may require the development of new persuasive strategies. This depends to some degree on whether the character is attempting to bring about attitude change or behaviour change. For example, a character beseeching another to adopt a new course of action might be able to apply a modified Warning strategy while a character attempting to persuade another to relinquish an object would require a new strategy altogether. Given the ASM's consideration of the affective aspects of dialogue this approach would also integrate very well with Interactive Storytelling systems which model character emotions.

## Related Publications

Cavazza, M., **Smith, C.**, Charlton, D., Zhang, L., Turunen, M. and Hakulinen, J. (2008) A ‘Companion’ ECA with Planning and Activity Modelling (Short Paper). In *Proceedings of the 7th International Conference on Autonomous Agents and Multiagent Systems* (AAMAS 2008), Estoril, Portugal, pages 1281-1284.

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**Smith, C.**, Cavazza, M., Charlton, D., Zhang, L., Turunen, M. and Hakulinen, J. (2008) Integrating Planning and Dialogue in a Lifestyle Agent (Short Paper). In *Proceedings of the 8th International Conference on Intelligent Virtual Agents* (IVA 2008), Lecture Notes in Computer Science, Springer Berlin / Heidelberg, 5208, pages 146–153.

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Cavazza, M., **Smith, C.**, Charlton, D., Crook, N., Boye, J., Pulman, S., Moilanen, K., Pizzi, D., Santos de la Camara, R. and Turunen, M. (2010) Persuasive Dialogue based on a Narrative Theory: an ECA Implementation. In *Proceedings of the 5th International Conference on Persuasive Technology (PERSUASIVE'10)*, Springer-Verlag, Berlin, Heidelberg, pages 250-261.

**Smith, C.**, Crook, N., Boye, J., Charlton, D., Dobnik, S., Pizzi, D., Cavazza, M., Pulman, S., Santos de la Camara, R. and Turunen, M. (2010) Interaction Strategies for an Affective Conversational Agent. In *Intelligent Virtual Agents*, Lecture Notes in Computer Science, Springer Berlin / Heidelberg, 6356, pages 301-314.

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## A. Appendix – Sources for ECA Images



**Figure 2.1:** *Examples of Embodied Conversational Agents.*

Figure 2.1 (reproduced above) shows some of the ECA discussed in Chapter 2. These pictures (clockwise from top left) were taken from the following sources:

- Steve
  - <http://www.isi.edu/isd/VET/steve-demo.html>
- Justina (Virtual Patient)
  - (Kenny et al, 2008)
- Cloddy Hans (NICE)
  - (Gustafson et al, 2005)
- REA
  - (Bickmore, 2003)
- Hans Christian Andersen (HCA)
  - (Bernsen and Dybkjær, 2005)
- Mission Rehearsal Exercise
  - (Traum et al, 2008)
- GRETA
  - <http://perso.telecom-paristech.fr/~pelachau/Greta/>
- LAURA (FitTrack)
  - (Bickmore, 2003)

## B. Appendix – Excerpt from Nixon Interview

Chapter 4 refers to a lengthy excerpt of an interview of Richard Nixon by David Frost. In the chapter this excerpt is abridged and annotated for reasons of space. The complete excerpt is presented below:

Frost: You have explained how you have got caught up in this thing, you've explained your motives: I don't want to quibble about any of that. But just coming to the substance: would you go further than "mistakes" - the word that seems not enough for people?

Nixon: What word would you suggest?

Frost: My goodness, that's a ... I think that there are three things, since you asked me. I would like to hear you say ... I think the American people would like to hear you say ... One is: there was probably more than mistakes; there was wrongdoing, whether it was a crime or not; yes it may have been a crime too. Second: I did - and I'm saying this without questioning the motives - I did abuse the power I had as president, or not fulfil the totality of the oath of office. And third: I put the American people through two years of needless agony and I apologise for that. And I say that you've explained your motives, I think those are the categories. And I know how difficult it is for anyone, and most of all you, but I think that people need to hear it and I think unless you say it you are going to be haunted by it for the rest of your life.

Nixon: I well remember when I let Haldeman and Erlichman know that they were to resign, that I had Ray Price [*Nixon's speechwriter*] bring in the final draft of the speech that I was to make the next night and I said to him, "Ray, if you think I ought to resign, put that in too, because I feel responsible." Even though I did not feel that I had engaged in these activities consciously in so far as the knowledge of, or participation in, the break-in, the approval of hush-money, the approval of clemency etc, there are various charges that have been made. Well, he didn't put it in, and I must say that at that time I seriously considered whether I shouldn't resign, but on the other hand I feel that I owe it to history, to point out that from that time on April 30, until I resigned on August 9, I did some things that were good for this country. We had the second and third summits. I think one of the major reasons I stayed in office, was my concern about keeping the China initiative, the Soviet initiative, the Vietnam fragile peace agreement and then an added dividend, the first breakthrough in moving toward - not love, but at least not war - in the Middle East. And, coming back to the whole point of whether I should have resigned then and how I feel now, let me say I didn't make mistakes in just this period; I think some of my mistakes that I regret most deeply came with the statements that I made afterwards. Some of those statements were misleading. I noticed, for example, the managing editor of the Washington Post, Ben Bradlee, wrote, a couple, three months ago, as far as his newspaper was concerned: "We don't print the truth; we print what we know, we print what people tell us and this means that we print lies."

Nixon: I would say that the statements that I made afterwards were, on the big issues, true - that I was not involved in the matters that I have spoken about; not involved in the break in; that I did not engage in, and

participate in, or approve the payment of money, or the authorisation of clemency, which of course were the essential elements of the cover-up - that was true. But, the statements were misleading in that enormous political attack I was under: it was a five-front war with a fifth column. I had a partisan senate committee staff, we had a partisan special prosecutors staff, we had a partisan media, we had a partisan judiciary committee staff, and a fifth column. Now under these circumstances, my reactions and some of these statements, from press conferences and so forth after that, I want to say right here and now, I said things that were not true. Most of them were fundamentally true on the big issues, but without going as far as I should have gone and saying perhaps that I had considered other things, but not done them. And for all those things I have a very deep regret.

Frost: You got caught up in something and it snowballed?

Nixon: It snowballed, and it was my fault. I'm not blaming anybody else. I'm simply saying to you that as far as I'm concerned, I not only regret it. I indicated my own beliefs in this matter when I resigned. People didn't think it was enough to admit mistakes; fine. If they want me to get down and grovel on the floor; no, never. Because I don't believe I should. On the other hand there are some friends who say, "just face 'em down. There's a conspiracy to get you." There may have been. I don't know what the CIA had to do. Some of their shenanigans have yet to be told, according to a book I read recently. I don't know what was going on in some Republican, some Democratic circles as far as the so-called impeachment lobby was concerned. However, I don't go with the idea that there ... that what brought me down was a coup, a conspiracy etc. I brought myself down. I gave them a sword, and they stuck it in and they twisted it with relish. And I guess if I had been in their position, I'd have done the same thing.

Frost: Could you just say, with conviction, I mean not because I want you to say it, that you did do some covering up. We're not talking legalistically now; I just want the facts. You did do some covering up. There was some time when you were overwhelmed by your loyalties or whatever else, you protected your friends, or maybe yourself. In fact you were, to put it at its most simple, part of a cover-up at times.

Nixon: No, I again respectfully will not quibble with you about the use of the terms. However, before using the term I think it's very important for me to make clear what I did not do and what I did do and then I will answer your question quite directly. I did not in the first place commit the crime of obstruction of justice, because I did not have the motive required for the commission of that crime.

Frost: We disagree on that.

Nixon: I did not commit, in my view, an impeachable offence. Now, the House has ruled overwhelmingly that I did. Of course, that was only an indictment, and it would have to be tried in the Senate. I might have won, I might have lost. But even if I had won in the Senate by a vote or two, I would have been crippled. And in any event, for six months the country couldn't afford having the president in the dock in the United States Senate. And there can never be an impeachment in the future in this country without a president voluntarily impeaching himself. I have impeached myself. That speaks for itself.

Frost: How do you mean "I have impeached myself"?

Nixon: By resigning. That was a voluntary impeachment. Now, what does that mean in terms of whether I ... you're wanting me to say that I participated in an illegal cover-up. No. Now when you come to the



period, and this is the critical period, when you come to the period of March 21 on, when Dean gave his legal opinion, that certain things, actions taken by, Haldeman, Erlichman, [attorney general John] Mitchell et cetera, and even by himself amounted to illegal coverups and so forth, then I was in a very different position. And during that period, I will admit, that I started acting as lawyer for their defence. I will admit, that acting as lawyer for their defence, I was not prosecuting the case. I will admit that during that period, rather than acting primarily in my role as the chief law enforcement officer of the United States of America, or at least with the responsibility of law enforcement, because the attorney general is the chief law enforcement officer, but as the one with the chief responsibility for seeing that the laws of the United States are enforced, that I did not meet that responsibility. And to the extent that I did not meet that responsibility, to the extent that within the law, and in some cases going right to the edge of the law in trying to advise Erlichman and Haldeman and all the rest in how best to present their cases, because I thought that they were legally innocent, that I came to the edge. And under the circumstances I would have to say that a reasonable person could call that a cover-up. I didn't think of it as a cover-up. I didn't intend it to cover-up.

Nixon: Let me say, if I intended to cover-up, believe me, I'd have done it. You know how I could have done it so easy? I could have done it immediately after the election simply by giving clemency to everybody. And the whole thing would have gone away. I couldn't do that because I said clemency was wrong. But now we come down to the key point and let me answer it in my own way about how I feel about the American people. I mean about whether I should have resigned earlier or what I should say to them now. Well, that forces me to rationalise now and give you a carefully prepared and cropped statement. I didn't expect this question, frankly though, so I'm not going to give you that. But I can tell you this ...

Frost: Nor did I.

Nixon: I can tell you this. I think I said it all in one of those moments that you're not thinking sometimes you say the things that are really in your heart. When you're thinking in advance and you say things that are, you know, tailored to the audience. I had a lot of difficult meetings in those last days and the most difficult one, the only one where I broke into tears, frankly except for that very brief session with Erlichman up at Camp David, that was the first time I cried since Eisenhower died. I met with all of my key supporters just the halfhour before going on television. For 25 minutes we all sat around the Oval Office, men that I had come to Congress with, Democrats and Republicans, about half and half. Wonderful men. And at the very end, after saying thank you for all your support during these tough years, thank you particularly for what you have done to help us end the draft, bring home the POWs, have a chance for building a generation of peace, which I could see the dream I had possibly being shattered, and thank you for your friendship, little acts of friendship over the years, you sort of remember with a birthday card and all the rest. Then suddenly you haven't got much more to say and half the people around the table were crying. And I just can't stand seeing somebody else cry. And that ended it for me. And I just, well, I must say I sort of cracked up. Started to cry, pushed my chair back.

Nixon: And then I blurted it out. And I said, "I'm sorry. I just hope I haven't let you down." Well, when I said: "I just hope I haven't let you down," that said it all. I had: I let down my friends, I let down the country, I let down

our system of government and the dreams of all those young people that ought to get into government but will think it is all too corrupt and the rest. Most of all I let down an opportunity I would have had for two and a half more years to proceed on great projects and programmes for building a lasting peace. Which has been my dream, as you know since our first interview in 1968 before I had any, when I thought I might win that year. I didn't tell you I thought I might not win that year, but I wasn't sure. Yep, I let the American people down. And I have to carry that burden with me for the rest of my life. My political life is over. I will never yet, and never again, have an opportunity to serve in any official position. Maybe I can give a little advice from time to time. And so I can only say that in answer to your question that while technically I did not commit a crime, an impeachable offence - these are legalisms. As far as the handling of this matter is concerned, it was so botched up, I made so many bad judgments. The worst ones mistakes of the heart rather than mistakes of the head, as I pointed out, but let me say a man in that top judge job, he's got to have a heart, but his head must always rule his heart.

## C. Appendix – HTN Planning Implementation

As discussed in Chapter 6, my HTN planner is inspired by the SHOP planner (Nau et al, 1999) and based on the standard Total-Order Forward Decomposition algorithm for HTN in (Ghallab et al, 2004). My implementation is written in Common Lisp and includes several standard extensions such as axiomatic inference and attached procedures (using Lisp). This Appendix provides further details of my implementation.

The HTN planner requires several parameters: the initial state of the world, the high level problem that will be decomposed and the domain. The domain is made up of a set of definitions for all the operators, methods, axioms and semantic evaluation rules that will be employed during the planning process. The problem is decomposed into an AND/OR tree with each node being either an AND node, an OR node, a task node or primitive task node (see Figure C.1).

The algorithm used in the planner is defined by the following pseudo-code:

```
Define Decompose-Task node
  If node = Task
    Find applicable methods
    If more than one method
      Add resulting tasks to OR node
      Add OR node to tree
      Decompose-Task with OR node
      Return result
    Else If one method
      Add resulting task to tree
      Decompose-Task with child node
      Return result
    Else If no methods
      Return failure
  Else If node = Primitive Task
    Find applicable operator
    If operator
      Apply operator to world state
      Add action to plan
      Return success
    If no operator
      Return failure
  Else If node = AND node
    For each child node
      Decompose-Task with child node
      If child returns success
        Continue with next child node
```

```

        Else If child returns failure
            Return failure
    Else If node = OR node
        Store world state and plan
        Calculate heuristics for each child node
        Use heuristic to select a child node
        With child node
            Decompose-Task with child node
            If child returns success
                Return success
            Else If child returns failure
                If more child nodes
                    Restore world state and plan
                    Select next child and repeat
                Else If no child nodes
                    Return failure

```

**Example C.1:** *Pseudo-code describing the HTN planner's algorithm.*

There are two main levels of control exercised over the planning process. The first and most basic level uses preconditions attached to the various methods to determine which methods are applicable, that is, can be applied in a given situation. From this set the second level of control, a heuristic selection process, is then performed which takes each of the applicable methods and uses various heuristics (defined as independent rules) to select which method will be applied. This is powerful as it provides a simple mechanism for harnessing a disparate selection of knowledge and enables a wide range of factors to come into play to influence the final selection. It can also provide variability as the heuristic selection mechanism can apply a random element so that the same method is not repeatedly applied for a given situation. When combined with the fact that this heuristic selection process occurs at multiple levels of the HTN, it allows for considerably more complexity and variance than is achievable with a scripted approach.

The definition of axioms, methods and operators within the domain is inspired by the Planning Domain Definition Language (PDDL) (Gerevini and Long, 2005) although, as PDDL does not fully support hierarchical planning domains, a custom definition is used. The operators and methods follow what is essentially the ADL requirement for PDDL actions (although typing is not used for variables with my domain). In addition to this basic range of functionality, Lisp expressions can be used such that preconditions can carry out mathematical operations and invoked attached procedures (written in

Lisp). The values of variables can also be referenced and assigned for use with these operations and procedures.

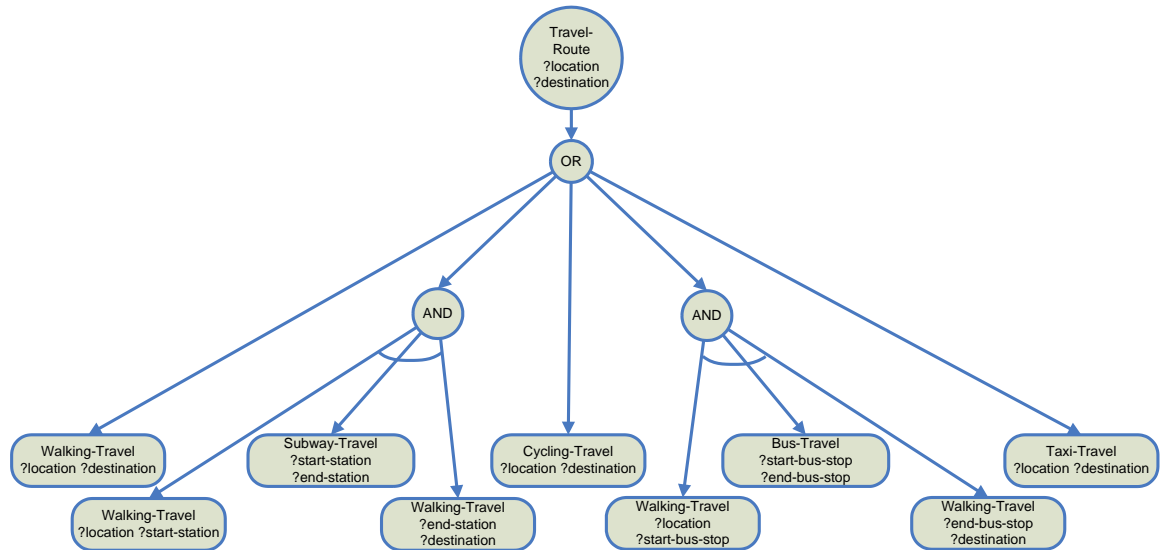
The rest of this appendix will present a discussion of a sample domain created for my HTN planner implementation. It will describe the format for methods, operators and semantic evaluation rules using examples taken from the sample domain. This is a sample travel domain derived from the Health & Fitness Companion describing the problem of selecting a means of travel based on the energy expenditure involved.

```
(Def-HTN-Method
  (Travel-Route ?location ?destination)
; pre-conditions
  (and
    (assign ?start-station
      (find-nearest-public-transport-location 'subway-travel
        (binding ?location)))
    (assign ?end-station
      (find-nearest-public-transport-location 'subway-travel
        (binding ?destination))))

; sub-tasks
  (and-branch
    ((primitive-task (Walking-Travel ?location ?start-station))
     (primitive-task (Subway-Travel ?start-station ?end-
station)))
    (primitive-task (Walking-Travel ?end-station
?destination))))

:semantic-tags
  ((:energy-expenditure-generic-travel part-walking-travel
?location ?start-station)
   (:energy-expenditure-subway-travel ?start-station ?end-
station)
   (:energy-expenditure-generic-travel part-walking-travel
?end-station ?destination)
   (:time-generic-travel part-walking-travel ?location
?start-station)
   (:time-subway-travel ?start-station ?end-station)
   (:time-generic-travel part-walking-travel ?end-station
?destination)
   (:public-transport-location-preference ?start-station)
   (:public-transport-location-preference ?end-station)
   (:travel-method-preference subway-travel ?start-station
?end-station)))
```

**Example C.2:** *Method definition for a sample Travel domain.*



**Figure C.1:** *Example of HTN Decomposition for the Travel-Route task*

Example C.2 shows the definition of a typical method within the sample travel domain. This method defines travel between ?location and ?destination using the subway. Alternative forms of travel between ?location and ?destination could be walking, cycling, bus travel or taking a taxi and each would have their own method defining this (see Figure C.1). There are pre-conditions attached to this method, namely that the system is able to find a subway station near to both the starting location and the destination. The pre-conditions make use of an attached procedure, the Lisp function Find-Nearest-Public-Transport-Location, along with ‘binding’ to determine the value of the ?location and ?destination variables and ‘assign’ to assign the resulting value to a new variable. (Note that ‘near’ merely indicates that a subway station is known to the system and, of those known, is nearest to the location provided.)

Assuming appropriate subway stations are found, the resulting sub-tasks for this method will involve spawning primitive tasks for walking to the first station, travelling via subway to the second station and walking from there to the destination. As these are primitive tasks, they are directly realisable by operators (i.e. Walking-Travel and Subway-Travel operators). The primitive tasks are also grouped under an AND-branch which indicates they are each required to be carried out in order. Example C.3 shows the definition of the Walking-Travel operator. The pre-conditions first check the required user information is found in the world state (and this also serves to assign this information to variables that will be used later). The user information, along with the location information from the parameter list, is then used to calculate new values (with

the help of some attached procedures) which are also assigned to variables. If at any point in the pre-conditions the planner is not able to determine the values it wants the resulting failure will cause the pre-conditions to fail and so the operator will be inapplicable.

```
(Def-HTN-Operator
(Walking-Travel ?loc-a ?loc-b)

; pre-conditions
(and
  (exist (planned-energy-expenditure ?current-energy))
  (exist (target-required-energy-expenditure ?target-
required-energy))
  (exist (user-weight ?weight))
  (exist (current-user-location ?loc-a))
  (assign ?time
    (calculate-travel-time 'walking-travel
      (Calculate-Shortest-Path (binding ?loc-a) (binding ?loc-
b) *road-map*)))
  (assign ?walking-energy
    (calculate-energy-expenditure 'walking-travel (binding
?weight) (binding ?time)))
  (assign ?inactivity-energy
    (calculate-energy-expenditure 'inactivity (binding
?weight) (binding ?time)))
  (assign ?gained-energy
    (- (binding ?walking-energy) (binding ?inactivity-
energy)))
  (assign ?new-planned-energy
    (+ (binding ?current-energy) (binding ?gained-energy)))
  (assign ?new-required-energy
    (let ((temp (- (binding ?target-required-energy) (binding
?gained-energy))))
      (if (< temp 0) 0 temp))))

; effects
(and
  (del-state (planned-energy-expenditure ?current-energy))
  (del-state (target-required-energy-expenditure ?target-
required-energy))
  (del-state (current-user-location ?loc-a))
  (add-state (current-user-location ?loc-b))
  (add-state (planned-energy-expenditure ?new-planned-
energy))
  (add-state (target-required-energy-expenditure ?new-
required-energy))))
```

**Example C.3:** *Operator definition for a sample Travel domain.*

Assuming the various pre-condition calculations are completed successfully, the operator's effects can be applied to the world state. In this example the operator is mainly concerned with updating the values for the user's energy expenditure for the day but the user's location is also updated. The old values are first deleted and then the new values are added.

The heuristic selection process makes use of semantic tagging, applied to each method, that describes the properties of the decomposition for that method. A set of heuristic rules, called semantic evaluation rules, are evaluated for each semantic tag. Each applicable semantic evaluation rule provides a score based on the current world state. Each applicable method is then sorted based on total score to determine the most suitable method for the current world state. Where some variability in output is desired, the selection process chooses those methods within a predefined threshold of the top score and these are then weighted (based on score) and a final method selected using a randomly generated number. This approach allows both for the desired variability while ensuring that the selection favours the most appropriate methods for the situation.

In the method example above, **Travel-Route** contains semantic tags that look at the time and energy that will be expended using this particular method. This needs to take into account both the actual subway travel as well as the walking stages that surround it. The semantic tags are provided with the information on the starting location, destination and intermediate stations so that these can be used to calculate the particular time and energy expenditure that will apply in this case. The semantic tags can also take into account more abstract influences, such as those involving the user's preferences both for subway travel (in general) and for the particular subway stations chosen (in particular). This might mean a bonus if the user is recorded as liking any of these, or a penalty if the user has a recorded dislike.

The actual definition of the semantic evaluation rules follow in a similar pattern to those of the methods and operators, with pre-conditions determining whether the rule should be applied and an expression providing the resulting score. In Example C.4 the subway travel time is given a score which takes into account the ?location and ?destination stations used. The pre-condition is used to determine the time for the journey with the help of the attached procedure **Calculate-Shortest-Path**. (Should this be unable to determine the time for this journey for some reason, the pre-condition will fail and so



the rule will not contribute a score to the final total.) The time (returned in minutes) then has various calculations applied to turn it into an appropriate value for a heuristic score. In this case, the shorter the journey the higher the score (with a journey of over an hour turning into a penalty).

```
(Def-HTN-Semantic-Eval-Rule
(:time-subway-travel ?location ?destination)

; pre-conditions
(assign ?time
  (Calculate-Shortest-Path (binding ?location) (binding
?destination) *subway-map*))

; score
(- 1 (/ (binding ?time) 60))))
```

**Example C.4:** *Semantic evaluation rule definition for a sample Travel domain.*

Any given semantic tag may trigger several semantic evaluation rules with all those semantic evaluations rules that are applicable providing a score which contributes to the final total. As seen previously in the example method, each method may also have several semantic tags attached. This makes the use and extension of the semantic tags and semantic evaluation rules fairly simple as each can be treated independently. However, it also provides for great power and complexity in the decision making process as many varied factors can come into play and affect the final choice of method.

## **D. Appendix – Additional ASM Data**

This Thesis has made extensive use of dialogue examples featuring conversation with the HWYD Companion. The main presentation of this information has included details of both user and system utterances, user affect and the ASM operators used to generate system utterances. This format is outlined in Chapter 6 and replicates the information provided by the HWYD Companion user interface (see Figure 7.2). This appendix will detail additional information not provided in the main body of the Thesis.

This appendix will consider the dialogue of Example 5.1 which is used to present the appraisal process and subsequently to discuss Reassuring strategy operators in Chapter 6. The full plan generated by the ASM, including performative information, is provided in Example 6.1 and the dialogue is presented again, this time with auxiliary information, in Example 6.2.

Example D.1 provides the XML sent by the DM when invoking the ASM to generate the narrative response of Example 5.1/6.2. This consists of a set of name/attribute pairs which define the information gathered from the NLU module.

Example D.2 provides the ASM state information resulting from the generation of the narrative response. This contains the processed DM information with additional data added such as the results of the appraisal process. This information is sent, along with the plan in Example 6.1, to the NLG module.

Finally, Example D.3 provides a complete trace of the HTN decomposition carried out by the ASM in the generation of the narrative response. This provides details of other applicable methods encountered during decomposition and semantic evaluation rule scores for alternate options.

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```

```

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**Example D.1:** *DM output initiating the narrative response of Example 5.1/6.2.*

(Agent-Focus User) (Agent-Outlook Optimistic) (Agent-Supportive True)  
 (Agent-Use-Of-Irony High) (Antagonist 1 Sarah) (Antagonist-Assessment 1 5)  
 (Antagonist-Count 1) (Antagonist-Id 1 P1) (Emo\_Value D1 Negative\_Passive)  
 (Emo\_Value D2 Negative\_Passive) (Emo\_Value E1 Negative\_Passive)  
 (Emo\_Value E2 Neutral) (Emo\_Value E3 Negative\_Passive)  
 (Emo\_Value E4 Negative\_Passive) (Emo\_Value E5 Negative\_Active)  
 (Emo\_Value Em1 Negative\_Passive) (Emo\_Value Em2 Negative\_Passive)  
 (Emo\_Value Em3 Negative\_Passive) (Emo\_Value Em4 Negative\_Passive)  
 (Emo\_Value Em5 Positive\_Passive) (Emo\_Value G1 Negative\_Passive)  
 (Emo\_Value P1 Negative\_Passive) (Emo\_Value P2 Negative\_Passive)  
 (Emotion 1 Em1) (Emotion 2 Em2) (Emotion 3 Em3) (Emotion 4 Em4)  
 (Emotion 5 Em5) (Emotion-Count 5) (Employ-Irony False) (Enabler-Count 0)  
 (Ev-Mood Negative\_Passive) (Event E4) (Event-Involves-User False)  
 (Event-Outcome Fail) (Event-Outcome-Complete 1 Decrease-Motivation)  
 (Event-Outcome-Complete-Count 1) (Event-Outcome-Fail 1 Conserve-Motivation)  
 (Event-Outcome-Fail-Count 1) (Event-Type Deterioration)  
 (Expressed-Agent-Opinion E4) (Helper 1 Sue) (Helper-Assessment 1 5)  
 (Helper-Count 1) (Helper-Id 1 P2) (Inanimate-Object-Count 0)  
 (Irony-Appropriate False) (Is\_User U1 True) (Likelihood E4 Possible)  
 (Likelihood E5 Certain) (Member D1 1 U1) (Members D1 1) (Members D2 0)  
 (Members E1 0) (Members E2 0) (Members E3 0) (Members E4 0) (Members E5 0)  
 (Members Em1 0) (Members Em2 0) (Members Em3 0) (Members Em4 0)  
 (Members Em5 0) (Members G1 0) (Members P1 0) (Members P2 0)  
 (Members U1 0) (Name D2 Logistics) (Name G1 Administrators) (Name P1 Sarah)  
 (Name P2 Sue) (Nature E1 User\_Day) (Nature E2 Office\_Politics)  
 (Nature E3 Merger) (Nature E4 Redundancy) (Nature E5 Argument) (Org-Unit 1 D1)  
 (Org-Unit 2 D2) (Org-Unit 3 G1) (Org-Unit-Count 3) (Owner Em1 G1)  
 (Owner Em2 P1) (Owner Em3 P2) (Owner Em4 U1) (Owner Em5 U1)  
 (Participant E1 1 U1) (Participant E2 1 U1) (Participant E3 1 D2)  
 (Participant E3 2 D1) (Participant E5 1 P1) (Participant E5 2 U1)  
 (Participant G1 1 P2) (Participant G1 2 P1) (Participants D1 0) (Participants D2 0)  
 (Participants E1 1) (Participants E2 1) (Participants E3 2) (Participants E4 0)  
 (Participants E5 2) (Participants Em1 0) (Participants Em2 0) (Participants Em3 0)  
 (Participants Em4 0) (Participants Em5 0) (Participants G1 2) (Participants P1 0)  
 (Participants P2 0) (Participants U1 0) (Person 1 P1) (Person 2 P2) (Person 3 U1)  
 (Person-Count 3) (Quality Em1 Worry) (Quality Em2 Hate) (Quality Em3 Hate)  
 (Quality Em4 Like) (Quality Em5 Dislike) (Strategy Reassuring) (Sub-Event 1 E1)  
 (Sub-Event 2 E2) (Sub-Event 3 E3) (Sub-Event 4 E5) (Sub-Event-Count 4)  
 (Sub-Event-Involves-User 1 True) (Sub-Event-Involves-User 2 True)  
 (Sub-Event-Involves-User 3 False) (Sub-Event-Involves-User 4 True)  
 (Target Em1 E4) (Target Em2 P2) (Target Em3 P1) (Target Em4 P2)  
 (Target Em5 P1) (Temporal\_Reference E1 Past) (Temporal\_Reference E2 Present)  
 (Temporal\_Reference E3 Present) (Temporal\_Reference E4 Future)  
 (Temporal\_Reference E5 Past) (Threat 1 Office\_Politics) (Threat 2 Merger)  
 (Threat 3 Argument) (Threat-Addressed E2) (Threat-Addressed E5)  
 (Threat-Assessment 1 6) (Threat-Assessment 2 6) (Threat-Assessment 3 8)  
 (Threat-Count 3) (Threat-Id 1 E2) (Threat-Id 2 E3) (Threat-Id 3 E5)  
 (Type D1 Department) (Type D2 Department) (Type G1 Group)  
 (User-Anticipation Complete) (User-Mood Negative\_Passive)  
 (User-Reaction Appropriate)

**Example D.2:** *ASM state information for narrative response of Example 5.1/6.2.*

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||||->#<HTN-Task Name:(RESOLVE-EVENT-TYPE) S:0 D:4>
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|||||->#<HTN-Primitive-Task Done:Y Name:(APPRAISE-USER-ANTICIPATION) No-Child S:0 D:4>
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|||||->#<HTN-Primitive-Task Done:Y Name:(APPRAISE-EVENT-USER-INVOLVEMENT) No-Child S:0 D:4>
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|||||->#<HTN-Primitive-Task Done:Y Name:(ADD-EVENT-OUTCOMES) No-Child S:0 D:4>
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|||||->#<HTN-Primitive-Task Done:Y Name:(DECIDE-ON-IRONY) No-Child S:0 D:4>
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|||||->#<HTN-Task Name:(APPRAISE-EVENT-INFLUENCES) S:0 D:4>
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```

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|||||>#<HTN-Task Name:(APPRAISE-PERSON 2) S:0 D:9>
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|||||>#<HTN-Task Name:(APPRAISE-PERSON 3) S:0 D:9>

```

```

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|||||>#<HTN-AND-Branch Children:3 S:0 D:10>
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| | | | | | | | | | --#<HTN-Task Name:(COMMENT-USER-ANTICIPATION) No-Child S:0 D:11>  
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| | | | | | | | | |  
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(COMMEND-RESPONSE-TO-GENERAL-SITUATION) No-Child S:3 D:13>  
| | | | | | | | | |  
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(COMMEND-RESPONSE-TO-SPECIFIC-SITUATION) No-Child S:3 D:13>  
| | | | | | | | | |  
| | | | | | | | | | ->#<HTN-Primitive-Task Done:Y Name:(STATE-AGREEMENT-REGARDING-SITUATION) No-Child S:3 D:13>  
| | | | | | | | | |  
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:13>  
| | | | | | | | | |  
| | | | | | | | | | ->#<HTN-Task Name:(COMMENT-USER-ANTICIPATION) S:0 D:11>  
| | | | | | | | | |  
| | | | | | | | | | ->#<HTN-OR-Branch Children:5 Ignored:N Reserve:N S:0 D:12>  
| | | | | | | | | |  
| | | | | | | | | | ->#<HTN-Primitive-Task Done:Y Name:(STATE-DISAGREEMENT-WITH-ANTICIPATION) No-Child S:3 D:13>  
| | | | | | | | | |  
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(STATE-CONTRASTING-AGENT-ANTICIPATION) No-Child S:3 D:13>  
| | | | | | | | | |  
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:13>
```

D. Appendix – Additional ASM Data Page **209** of **215**

```

|||||->#<HTN-OR-Branch Children:2 Ignored:N Reserve:N S:0 D:6>
|||||
|||||->#<HTN-OR-Branch Children:2 Ignored:N Reserve:N S:5 D:7>
|||||
|||||->#<HTN-AND-Branch Children:2 S:0 D:8>
|||||
|||||->#<HTN-Task Name:(EXPRESS-AGENT-ATTITUDE-TO-MAIN-EVENT) S:0 D:9>
|||||
|||||->#<HTN-Primitive-Task Done:Y Name:(DO-NOTHING) No-Child S:0 D:10>
|||||
|||||->#<HTN-Task Name:(COMMENT-OUTCOME) S:0 D:9>
|||||
|||||->#<HTN-OR-Branch Children:3 Ignored:N Reserve:1 S:0 D:10>
|||||
|||||--#<HTN-OR-Branch Children:2 Ignored:N Reserve:N S:0 D:11>
|||||
|||||--#<HTN-Task Name:(OUTCOME-IS-FAIR CONSERVE-MOTIVATION) No-Child S:0 D:12>
|||||
|||||--#<HTN-Task Name:(EXPRESS-LIKELIHOOD-OF-OUTCOME CONSERVE-MOTIVATION) No-Child S:0 D:12>
|||||
|||||--#<HTN-OR-Branch Children:2 Ignored:N Reserve:N S:0 D:11>
|||||
|||||--#<HTN-Task Name:(PLAY-DOWN-LIKELIHOOD-OF-OUTCOME DECREASE-MOTIVATION) No-Child S:0 D:12>
|||||
|||||--#<HTN-Task Name:(PLAY-DOWN-WORRY-ABOUT-OUTCOME DECREASE-MOTIVATION) No-Child S:0 D:12>
|||||
|||||->#<HTN-OR-Branch Children:6 Ignored:N Reserve:N S:0 D:11>
|||||
|||||--#<HTN-Primitive-Task Done:N Name:(EXPRESS-LIKELIHOOD-OF-RESULT PRE-ACTUALISATION FIND-ADDITIONAL-
FUNDING EVENT-PREVENTED NIL) No-Child S:0 D:12>
|||||
|||||--#<HTN-Primitive-Task Done:N Name:(RESULT-IS-FAIR PRE-ACTUALISATION FIND-ADDITIONAL-FUNDING EVENT-
PREVENTED NIL) No-Child S:0 D:12>
|||||
|||||--#<HTN-Primitive-Task Done:N Name:(EXPRESS-LIKELIHOOD-OF-RESULT EVENT-ACTUALISED GET-RID-OF-DIFFICULT-
COLLEAGUES POSITIVE-AFTERMATH NIL) No-Child S:0 D:12>
|||||

```

```

|||||---#<HTN-Primitive-Task Done:N Name:(RESULT-IS-FAIR EVENT-ACTUALISED GET-RID-OF-DIFFICULT-COLLEAGUES
POSITIVE-AFTERMATH NIL) No-Child S:0 D:12>
|||||
|||||---#<HTN-Primitive-Task Done:N Name:(EXPRESS-LIKELIHOOD-OF-RESULT EVENT-ACTUALISED ONLY-VOLUNTARY-
REDUNDANCIES POSITIVE-AFTERMATH NIL) No-Child S:0 D:12>
|||||
|||||---#<HTN-Primitive-Task Done:Y Name:(RESULT-IS-FAIR EVENT-ACTUALISED ONLY-VOLUNTARY-REDUNDANCIES
POSITIVE-AFTERMATH NIL) No-Child S:0 D:12>
|||||
|||||-----
|||||
|||||---#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:-536870912 D:11>
|||||
|||||---#<HTN-AND-Branch Children:2 S:0 D:8>
|||||
|||||---#<HTN-Task Name:(COMMENT-OUTCOME) No-Child S:0 D:9>
|||||
|||||---#<HTN-Task Name:(EXPRESS-AGENT-ATTITUDE-TO-MAIN-EVENT) No-Child S:0 D:9>
|||||
|||||---#<HTN-Task Name:(COMMENT-OUTCOME) No-Child S:-1 D:7>
|||||
|||||---#<HTN-Task Name:(COMMENT-PROCESS) S:0 D:5>
|||||
|||||---#<HTN-OR-Branch Children:3 Ignored:N Reserve:1 S:0 D:6>
|||||
|||||---#<HTN-Task Name:(FOCUS-ON-NEGATIVE-INFLUENCES) S:8 D:7>
|||||
|||||---#<HTN-OR-Branch Children:4 Ignored:N Reserve:N S:0 D:8>
|||||
|||||---#<HTN-AND-Branch Children:3 S:0 D:9>
|||||
|||||---#<HTN-Task Name:(COMMENT-THREATS) No-Child S:0 D:10>
|||||
|||||---#<HTN-Task Name:(COMMENT-ABILITY) No-Child S:0 D:10>
|||||
|||||---#<HTN-Task Name:(COMMENT-ANTAGONISTS) No-Child S:0 D:10>
|||||

```

```

||||| |--#<HTN-AND-Branch Children:3 S:0 D:9>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-ABILITY) No-Child S:0 D:10>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-THREATS) No-Child S:0 D:10>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-ANTAGONISTS) No-Child S:0 D:10>
||||| |
||||| |--#<HTN-AND-Branch Children:3 S:0 D:9>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-ABILITY) No-Child S:0 D:10>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-THREATS) No-Child S:0 D:10>
||||| |
||||| |--#<HTN-Task Name:(COMMENT-ANTAGONISTS) No-Child S:0 D:10>
||||| |
||||| |->#<HTN-AND-Branch Children:3 S:0 D:9>
||||| |
||||| |->#<HTN-Task Name:(COMMENT-ANTAGONISTS) S:0 D:10>
||||| |
||||| |->#<HTN-OR-Branch Children:3 Ignored:N Reserve:N S:0 D:11>
||||| |
||||| |->#<HTN-Primitive-Task Done:Y Name:(PLAY-DOWN-ANTAGONIST P1) No-Child S:13 D:12>
||||| |
||||| |--#<HTN-Primitive-Task Done:N Name:(WARN-ANTAGONIST P1) No-Child S:11 D:12>
||||| |
||||| |--#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:12>
||||| |
||||| |->#<HTN-Task Name:(COMMENT-ABILITY) S:0 D:10>
||||| |
||||| |->#<HTN-OR-Branch Children:3 Ignored:N Reserve:N S:0 D:11>
||||| |
||||| |->#<HTN-Primitive-Task Done:Y Name:(PROMOTE-USER-ABILITY) No-Child S:3 D:12>
||||| |
||||| |--#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:12>
||||| |
||||| |--#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:12>

```

```

|||||
| | | | | | | | | | ->#<HTN-Task Name:(COMMENT-THREATS) S:0 D:10>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-OR-Branch Children:2 Ignored:N Reserve:N S:0 D:11>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(COMMENT-THREAT) No-Child S:0 D:12>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-AND-Branch Children:2 S:0 D:12>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Task Name:(COMMENT-THREAT) S:0 D:13>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-OR-Branch Children:7 Ignored:N Reserve:N S:0 D:14>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Task Name:(PLAY-DOWN-THREAT E5) S:10 D:15>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Primitive-Task Done:Y Name:(PLAY-DOWN-THREAT E5) No-Child S:0 D:16>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(PLAY-DOWN-THREAT E2) No-Child S:8 D:15>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(PLAY-DOWN-THREAT E3) No-Child S:8 D:15>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(WARN-THREAT E5) No-Child S:8 D:15>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(WARN-THREAT E2) No-Child S:6 D:15>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Task Name:(WARN-THREAT E3) No-Child S:6 D:15>
| | | | | | | | | |
| | | | | | | | | | --#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:15>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Task Name:(COMMENT-THREAT) S:0 D:13>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-OR-Branch Children:5 Ignored:N Reserve:N S:0 D:14>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Task Name:(PLAY-DOWN-THREAT E2) S:8 D:15>
| | | | | | | | | |
| | | | | | | | | | ->#<HTN-Primitive-Task Done:Y Name:(PLAY-DOWN-THREAT E2) No-Child S:0 D:16>
| | | | | | | | | |

```

```

|||||---#<HTN-Task Name:(PLAY-DOWN-THREAT E3) No-Child S:8 D:15>
|||||
|||||---#<HTN-Task Name:(WARN-THREAT E2) No-Child S:6 D:15>
|||||
|||||---#<HTN-Task Name:(WARN-THREAT E3) No-Child S:6 D:15>
|||||
|||||---#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:0 D:15>
|||||
|||||---#<HTN-Task Name:(CONTRAST-ACTOR-INFLUENCES) No-Child S:7 D:7>
|||||
|||||---#<HTN-Task Name:(FOCUS-ON-POSITIVE-INFLUENCES) No-Child S:4 D:7>
|||||
|||||-----
|||||
|||||---#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:-536870912 D:7>
|||||
||||---#<HTN-AND-Branch Children:3 S:5 D:4>
|||||
|||||---#<HTN-Task Name:(COMMENT-PROCESS) No-Child S:0 D:5>
|||||
|||||---#<HTN-Task Name:(ADDRESS-OUTCOME) No-Child S:0 D:5>
|||||
|||||---#<HTN-Task Name:(RESPOND-TO-USER-REACTION) No-Child S:0 D:5>
|||||
||||---#<HTN-AND-Branch Children:3 S:3 D:4>
|||||
|||||---#<HTN-Task Name:(COMMENT-PROCESS) No-Child S:0 D:5>
|||||
|||||---#<HTN-Task Name:(RESPOND-TO-USER-REACTION) No-Child S:0 D:5>
|||||
|||||---#<HTN-Task Name:(ADDRESS-OUTCOME) No-Child S:0 D:5>
|||||
||||---#<HTN-AND-Branch Children:3 S:3 D:4>
|||||
|||||---#<HTN-Task Name:(ADDRESS-OUTCOME) No-Child S:0 D:5>
|||||
|||||---#<HTN-Task Name:(RESPOND-TO-USER-REACTION) No-Child S:0 D:5>

```

```

|||||
|||||--#<HTN-Task Name:(COMMENT-PROCESS) No-Child S:0 D:5>
|||||
|||||--#<HTN-AND-Branch Children:3 S:-2 D:4>
|||||
|||||--#<HTN-Task Name:(RESPOND-TO-USER-REACTION) No-Child S:0 D:5>
|||||
|||||--#<HTN-Task Name:(COMMENT-PROCESS) No-Child S:0 D:5>
|||||
|||||--#<HTN-Task Name:(ADDRESS-OUTCOME) No-Child S:0 D:5>
|||||
|||||--#<HTN-AND-Branch Children:3 S:-2 D:4>
|||||
|||||--#<HTN-Task Name:(ADDRESS-OUTCOME) No-Child S:0 D:5>
|||||
|||||--#<HTN-Task Name:(COMMENT-PROCESS) No-Child S:0 D:5>
|||||
|||||--#<HTN-Task Name:(RESPOND-TO-USER-REACTION) No-Child S:0 D:5>
||
||->#<HTN-Task Name:(CONCLUSION) S:0 D:2>
|||
|||->#<HTN-OR-Branch Children:1 Ignored:N Reserve:1 S:0 D:3>
|||
|||->#<HTN-Primitive-Task Done:Y Name:(PROVIDE-MORAL) No-Child S:0 D:4>
|||
|||-----
|||
|||--#<HTN-Primitive-Task Done:N Name:(DO-NOTHING) No-Child S:-536870912 D:4>

```

**Example D.3:** HTN decomposition for narrative response of Example 5.1/6.2.